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FRANKLIN MOON, *Dean*

Roosevelt Wild Life Annals

VOLUME 1

NUMBERS 3 and 4

OF THE

Roosevelt Wild Life Forest Experiment Station



THE ECOLOGY AND ECONOMICS OF ONEIDA LAKE FISH

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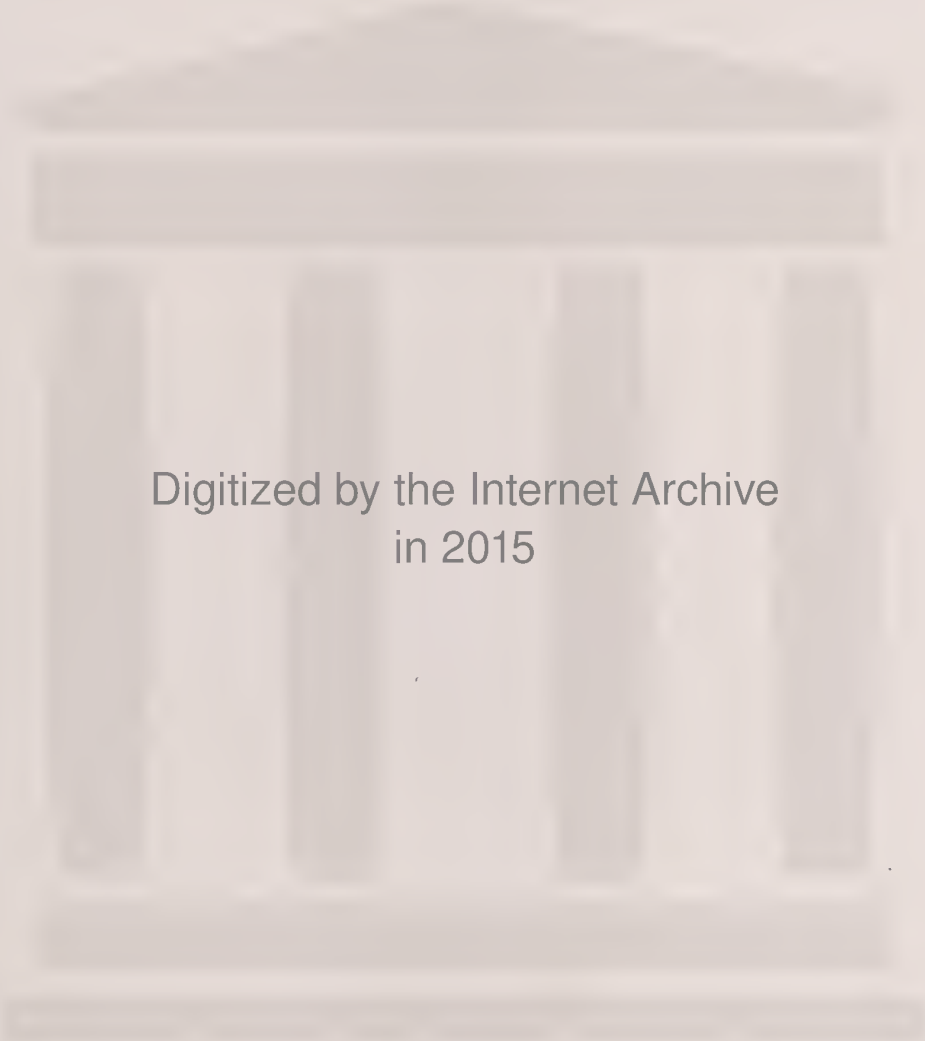
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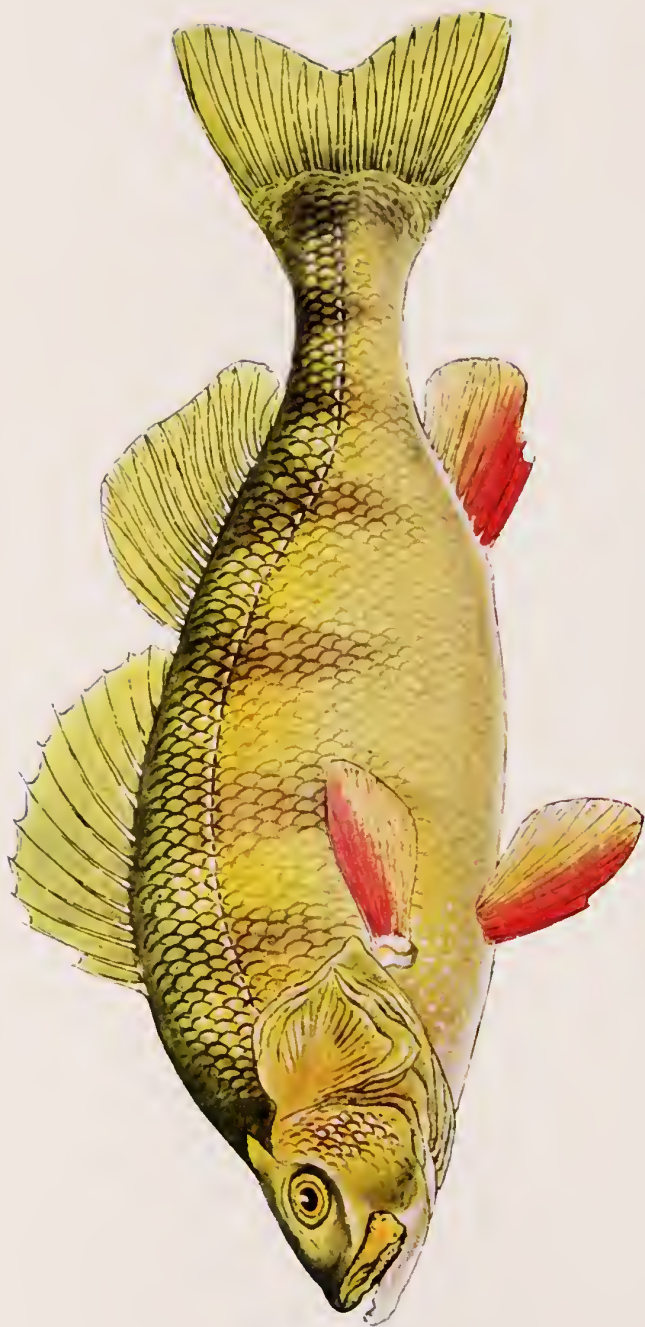


Plate I. YELLOW PERCH, *Perca flavescens* Mitchell.

THE ECOLOGY AND ECONOMICS OF ONEIDA LAKE FISH

By CHARLES C. ADAMS,* *Collaborator, Animal Ecologist*

and

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INTRODUCTION AND ACKNOWLEDGMENTS

The present report on the fish of Oneida Lake is part of a comprehensive plan devoted to the study of the fish and fisheries of these waters, and is the result of special field studies and collections made by several persons and covering a period of years. It was begun by the senior author in 1914 and carried on more extensively with the assistance of the junior author and others, during the summers of 1915-1917, while in 1921 some studies of the fish of the lake in winter and in spring were conducted. A brief survey of the shore fishes was made in September 1927, by Mr. Wilford A. Dence, Professor T. L. Hankinson and Dr. Charles E. Johnson.

The major objective of these investigations was to make a contribution toward a system of fish cultural management for the lake. The detailed results of several special studies on the molluscan food of the fishes of Oneida Lake have already been published by Baker ('16), who later ('18) made an intensive quantitative study of the productivity of the macroscopic invertebrate fish food in the shallow water of Lower South Bay, which is on the south shore of the lake. Still later, Baker assisted Professor Henry S. Pratt in making a study of the worm parasites of the fishes of the lake, the results of which were published by Pratt ('23) and Van Cleave ('23). A preliminary list of the fish was published ('16) by the present authors. Intensive field studies by the Roosevelt Station staff were then interrupted by similar investigations demanding attention in the Palisades Interstate Park, in the Allegany State Park, Erie County, and in Cranberry Lake in the Adirondacks. Considerable work had already been done in the preparation of this report, but since the two authors severed their connection with the Roosevelt Wild Life Station, a special effort has been made to get this progress report in shape for publication. The limited time available necessitated considerable abbreviation of the original plan, although an effort was made to bring the accounts of the various species reasonably up to date.

Too often in the past, fish cultural policies have been worked out upon inadequate data, not even using those already recorded, because of their relative inaccessibility and the time and exertion required to assemble them. To aid in the execution of the present plan, the following detailed outline was prepared for each of the 59 species of fish, and an effort was made to bring together the most important facts regarding their life histories, habits, ecology and economics, and their status in Oneida Lake so far as learned in the course of the survey. Each species is treated under the following headings.

1. *General*. (Status in Oneida Lake)
2. *Breeding Habits and Life History*.
 - Mating
 - Nest building
 - Egg laying
 - Hatching
 - Rate of growth
 - Maturity
 - Size
3. *Habitat*. (Influence of season, age, water, bottom, temperature, and plants)
4. *Food*. (Feeding habits, senses, kind of food)
5. *Distribution Records*.
6. *Enemies, Diseases, etc.*
7. *Economic Relations*.
 - (Control or culture)
8. *Angling Notes*.
 - (Bait, etc.)
9. *References*.

In such summaries it is of course impossible to vouch for the reliability of all the source material utilized, or to attempt to unravel the taxonomic confusion involved, as in the case of parasites, for example; but to bring all the available information together was considered a necessary preliminary step in working toward a sound basis for fish culture. The 59 species found in Oneida Lake have been made the object of such a summarizing treatment in the hope that this will lead to the improvement of current practices. Nevertheless, it is our main regret that other duties and obligations have prevented the comprehensive organization of all these data into a more serious provisional policy for these waters.

Although the authors have been unable to work out, in the way they had hoped, the detailed applications of their studies to Oneida Lake, various other studies conducted by the Roosevelt Station staff have, during this interval, had a very distinct bearing upon Oneida Lake. Thus Dr. Kendall's report ('24) on fish culture in public waters discusses policies which apply directly to this lake, and merits the careful attention of any future student of this problem. If intensive fish culture should include the attempt to control the abundance of leeches in the lake, then Dr. J. Percy Moore's ('23) study of this problem will prove valuable. Since these investigations were first begun on Oneida Lake, there has been a very great increase in the number of summer homes and cottages on the shores of the lake. The shores are generally low, with many bogs and swampy marginal areas. These areas will sooner or later raise the question of mosquito control, and in that case the studies which Moore ('22) also made, in cooperation with the Roosevelt Station, in the Palisades Interstate Park, will prove of value because he gave special attention to fishes as a means of controlling these pests. In time, attention may be turned to the "water bloom" algae, and their control, and in that case Smith's ('24) discussion of the control of algae by chemicals, and the influence of these chemicals on fish, will prove of value. With the transformation of the territory about the lake from an area with a relatively small population to one of intensive use as a resort and for recreational purposes, there will need to be made important adaptive changes in the fish cultural policy.

The field studies have been based upon extensive collections of fishes secured during a complete circuit of the lake in this survey, and upon other collections made during a period of about 14 years. The bulk of the collections are from the

shallow waters, although through the assistance of the officials of the Oneida Hatchery at Constantia, on the north shore, collections in deeper water were also secured, and many additional specimens were bought from the fish market at Brewerton, through the aid of Messrs. Davison and Coville.

The determination of the taxonomic questions has fallen to the junior author, assisted by Dr. W. C. Kendall, Dr. H. W. Fowler, Dr. Carl Hubbs and Mr. Wilford A. Dence. Dr. Hubbs made available the extensive collections of fish at the Museum of Zoology at Ann Arbor and in addition freely gave an abundance of his time in helping with the determination of difficult forms, such as the small *Notropis*. The Oneida Lake collections, as has been stated, are extensive and are generally accompanied by detailed field notes and numerous photographs.

We wish to express our appreciation to the former Dean of the New York State College of Forestry, Dr. Hugh P. Baker, who earnestly aided the initiation of these investigations; to the present Dean of the College, Franklin F. Moon; to Division Chief W. H. Weston, of the New York State Department of Conservation; and to the Commission itself for various favors; to Messrs. Davison and Coville, fish dealers of Brewerton, N. Y., for valuable assistance; and to the various naturalists and local residents who have cooperated in some manner. To members of the Roosevelt Station Staff at the time, to the Director, Dr. Charles E. Johnson, Assistant Director Alvin G. Whitney, and to Dr. W. C. Kendall and Mr. Wilford A. Dence, Ichthyologists, we are under many obligations for assistance. The authors also wish to thank the Field Museum of Natural History of Chicago for the use of the 13 cuts of fish used in this report. The colored plates were made in cooperation with the Commissioners of the Palisades Interstate Park.



Fig. 175. Oneida Lake investigating party at the field laboratory, near South Bay, summer of 1916.



Fig. 176. Field party and collecting equipment at Mathews Point, June 23, 1916.



Fig. 177. General view of Oneida Lake from a point near Constantia. Looking south-west towards Frenchman's and Dunham's Island. Sept. 9, 1927.



Fig. 178. General view of the lower end of Oneida Lake from Oneida River bridge at Brewerton. Sept. 9, 1927.

GENERAL DESCRIPTION OF ONEIDA LAKE

By CHARLES C. ADAMS

Location and Physical Features. Oneida Lake lies about 11 miles north of Syracuse, N. Y. It is the largest lake lying wholly within the State. Lakes Erie, Ontario and Champlain are of course larger but extend beyond the limits of the State. As the glacial lakes which formed the ancestors of the present Great Lakes were drained, one of the depressions became Oneida Lake. It lies largely in an east and west direction, is 21 miles long, and has a maximum width of about 5.5 miles. The prevailing westerly and southwesterly winds are thus allowed a long sweep. The lake is 369 feet above the sea, and has a maximum depth of about 55 feet near the north shore, off the village of Cleveland. Its area is about 80 square miles (51,200 acres) and its shore line totals 65 miles. It drains through the Oneida and Oswego Rivers into Lake Ontario at Oswego. Baker ('16, p. 31) estimated from the Lake Survey map (Chart No. 4, N. Y. State Canals, Lake Survey, U. S. War Dept.) that the shallow water area, 6 feet or less in depth, includes about 6.8 square miles or 4,352 acres. If a depth of 12 feet or less be chosen, there would be 8,343 acres or slightly over 13 square miles of shallow waters. The lake is thus primarily a shallow water lake with low, extensive and swampy wooded shores (Figs. 194, 195, 196), bordered by cultivated fields. The main inflowing streams are Fish Creek, Oneida Creek, and Chittenango Creek. The ice averages between one and two feet in thickness and has been known to reach a thickness of three feet. It generally forms in December and "goes out" in April.

Waves on a lake of this character have considerable influence. The State Barge Canal passes lengthwise through the lake, and the storms and waves have been recognized as a serious menace here as compared with the condition in the usual canal waters. An examination of the bottom soundings (Map 16) about the larger islands, "reefs," and the exposed points or headlands, clearly shows wave-cut terraces resulting from wave erosion and transportation (Figs. 212, 217 and 218). There are no rock outcrops along the shores of the lake, all being composed of unconsolidated glacial and postglacial deposits. The materials from cut terraces and truncated forelands have been carried to deeper waters and into the bays, where, with drifting sand and organic débris, deposition has been active. The periodic fluctuations of the lake level, and the canalization (cf. Whitford, '05) of its waters with its dams and locks, have had their influence also.

The drainage area of the lake, according to Rafter ('05, p. 219), includes 1,265 square miles. Much of this area is low swampy land (Figs. 196, 197), with an abundance of vegetable débris, and there are considerable areas of sandy soil. The lake itself lies wholly in the Clinton shales and limestones, and a large part of the drainage is from the Medina sandstone area on the north. The extensive sandy glacial deposits along the north side of the lake are largely from this source, and the sandy delta-beach formed at the east end of the lake by Fish and Oneida Creeks—Sylvan Beach—is from these glacial sands (Fig. 216). The significance of this is that the drainage from these lands brings into the lake soluble minerals

and dissolved organic materials, which become food for plants and thus enrich or fertilize the water of the lake, making it a more favorable culture medium for aquatic vegetation, and ultimately a source of food for fish. Since Oneida Lake is in the St. Lawrence drainage it is, as Clarke ('24, p. 19) has shown, essentially a calcium carbonate solution, or "hard" water, and he calculates that each year 10.4 tons of soluble inorganic materials are removed from a square mile of this land by drainage. The "cyclic sodium" that is carried inland by the winds from the sea, amounts to between .3 and .4 parts per million in the region of this lake (cf. Jackson, '05, for maps). In addition to the mineral enrichment, there is an amount of nutriment derived from solutions obtained from plants and animals, as shown for Wisconsin lakes by Birge and Juday ('26). The "dust-detritus" of plants, to which Petersen called attention, and which Baker ('18, p. 41) pointed out for Oneida Lake, consists of fragmented material, remains of both plants and animals, including no doubt also the excrement from numerous animals, and deserves careful attention in this lake. In the course of a year many thousands of tons of decaying plants and animals, including algae, gross water plants, Mayflies, and dead fish, are circulated in this culture medium. The drainage and products of the lake itself are therefore favorable to the enrichment of the waters (Adams, '15, pp. 23-24). As the lake is shallow, the waters are readily warmed during the spring and summer and with the inwash of food materials, permit rooted vegetation (Fig. 182) to secure nourishment from the soil (Pond, '05; Kofoed, '03, p. 484), both the rooted and non-rooted plants finding particularly favorable conditions for luxuriant growth, much of which in turn becomes forage for aquatic animals, and ultimately food for most of the fish.

The shallow waters, as has been stated, abound in aquatic plants (Figs. 205, 206, 211), including at certain seasons vast amounts of minute plankton algae and other kinds as well, in addition to rooted and non-rooted gross vegetation, particularly in the protected coves and bays. Many of the details of this vegetation have been illustrated and recorded by Baker ('16, '18) and House ('18).

In connection with comprehensive plans for this fish survey, provision was made for a chemical and a temperature survey of the lake. An appropriation was secured to start the work, a chemist and equipment, including deep-sea thermometers, were secured, but later this had regretfully to be abandoned. Although chemical data for Oneida Lake are lacking, from what is known elsewhere it seems safe to conclude that the hydrogen ion concentration, the relative degree of alkalinity or acidity (pH), in Oneida Lake is less than in Lake Ontario, where Volman and Hannan ('21) found that pH was 7.8 in March, and 8.8 in August. Neutrality is at pH 7.0, so these waters are therefore alkaline. Although Oneida Lake is in the same drainage, its very abundant vegetation would be expected to increase the alkalinity, and the organic débris to decrease it; but on the average it should remain alkaline. The seasonal temperature stratification of the lake undoubtedly causes vertical differences also in the hydrogen ion concentration.

The Microscopic Food Supply. As in main part attention has been concentrated on the macroscopic animals of the lake, a few unpublished notes on the microscopic forms are here recorded. Since this paper went to press Muenchner ('28, pp. 140-157, Suppl. N. Y. Cons. Dept., 17th, Ann. Rep.) has published recent observations on the plant plankton of Oneida Lake. Dr. Gilbert M. Smith visited Oneida Lake August 30, 1918, and listed the following plankton algae:

PLANKTON ALGAE

"The letters following the specific names, R (rare) and S (scarce), refer to the relative abundance of the various organisms in the plankton catch and not to their relation to the total volume of the lake."

Chlorophyceae

<i>Kirchneriella lunaris</i> sss	<i>Botryococcus Braunii</i> rrr
<i>Dictyosphaerium pulchellum</i> rrr	<i>Pediastrum Boryanum</i> rr
<i>Sphaerocystis Schroeteri</i> ss	<i>Pediastrum duplex clathratum</i> rrr
<i>Cocystis Borgei</i> rrr	<i>Coclastrum reticulatum</i> rrr
<i>Scenedesmus quadricauda</i> rrr	<i>Staurostrum gracile</i> (?) rr

Myxophyceae

<i>Trichodesmium lacustre</i> sss	<i>Coelosphaerium Kuetzingianum</i> r
<i>Gloetrichia echinulata</i> s	<i>Coelosphaerium Naegelianum</i> rr
<i>Microcystis aeruginosa</i> rr	<i>Chroococcus limneticus</i> rrr
<i>Anabaena flos-aquae</i> rrr	<i>Merismopedia elegans</i> rr

Phaeophyceae

<i>Uroglenopsis americana</i> rrr	<i>Dinobryon cylindricum</i> rrr
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Every local resident about the lake is familiar with the great periodic abundance of water "bloom" which fills the surface waters during the summer months. Dr. Gilbert Smith found that this was *Gloetrichia echinulata*. (Cf. '24, p. 104.)

ANIMAL PLANKTON

Mr. Alfred A. Doolittle, of Washington, D. C., visited Oneida Lake during July, 1916, and made a few collections. His records, which he has kindly permitted us to use, are as follows:

ENTOMOSTRACA

Collected off Norcross Point, July 18, 1916.

No. 1, 2 p. m., after 18 hours of northeast wind. Towing 2 feet of water among a few weeds.

No. 2, 2:30 p. m., after 18 hours of northwest wind, one-fourth mile from shore. Towing surface, and down to 15 feet.

No. 3, New York State College of Forestry coll. No. 580 A. Towing, about 7 p. m.

No. 4, New York State College of Forestry coll. No. 580 B. Towing, about 9 p. m.

No. 5, New York State College of Forestry coll. No. 581 A. Towing near shore, sparse weeds, 7 p. m. Collection about 5 cc.

No. 6, New York State College of Forestry coll. No. 581 B. Towing near shore, sparse weeds, 9 p. m. Collection about 125 cc.

Towings Nos. 5 and 6 were over identical courses, and illustrate the difference, in amount at least, between day and night collecting.

NAME	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
<i>Epischura lacustris</i> Forbes.....	x	x	x	x	x	.....
<i>Diaptomus minutus</i> Lilljeborg.....	x	x	x	x	x	x
<i>Cyclops viridis brevispinosus</i> Herrick.....	x	x	.....	.....	.....	x
<i>Cyclops leuckarti</i> Claus.....	x	x	x	x	x	.....
<i>Cyclops serrulatus</i> Fiseher.....	x	.....	.....	.....	.....	x
<i>Canthocamptus staphylinus</i> (Jurine).....	x	.....	.....	.....	.....	.....
<i>Sida crystallina</i> (O. F. Müller).....	x	x	x	x	x	x
<i>Diaphanosoma brachyurum</i> (Lieven).....	x	x	.....	x	x	.....
<i>Daphnia arcuata</i> (?) Forbes.....	.....	x	.....	.....	.....	.....
<i>Daphnia retrocurva</i> Forbes.....	.....	.....	x	x	.....	.....
<i>Daphnia longispina hyalina</i> (forma) Leydig..	x	x	x	x	x	.....
<i>Simocephalus vetulus</i> (O. F. Müller).....	.....	.....	.....	.....	.....	x
<i>Ceriodaphnia lacustris</i> Birge.....	.....	.....	.....	.....	x	.....
<i>Camptocercus rectirostris</i> Schoedler.....	x	.....	.....	.....	.....	.....
<i>Acroperus harpae</i> Baird.....	x	.....	.....	.....	x	.....
<i>Alona guttata</i> Sars.....	x	.....	.....	.....	.....	.....
<i>Alona affinis</i> (Leydig).....	x	.....	.....	.....	.....	.....
<i>Alona quadrangularis</i> (O. F. Müller).....	x	.....	.....	.....	.....	x
<i>Alona costata</i> Sars.....	x	.....	.....	.....	.....	.....
<i>Alona rectangula</i> Sars.....	x	.....	.....	.....	.....	x
<i>Alona pulchra</i> Hellich.....	x	.....	.....	.....	.....	x
<i>Pleuroxus denticulatus</i> Birge.....	x	.....	.....	.....	.....	.....
<i>Chydorus globosus</i> Baird.....	.....	x	.....	.....	.....	x
<i>Chydorus gibbus</i> Lilljeborg.....	x	.....	.....	.....	x	x
<i>Chydorus sphaericus</i> (O. F. Müller).....	.....	x	.....	.....	.....	.....
<i>Alonella nana</i> (Baird).....	x	.....	.....	.....	.....	.....
<i>Leptodora kindtii</i> (Focke).....	x	x	x	x	x	x

"*Chydorus gibbus* has been recognized apparently, in this country only from Lake Superior, except now in Oneida Lake."

Collected off Three Mile Bay, July 19, 1916.

No. 1, New York State College of Forestry coll. No. 582 A. Towing in open water among water plants, water temperature 82° F, wind southeast, about 8 miles per hour.

No. 2, New York State College of Forestry coll. No. 582 B. Towing among water weeds, water temperature 82° F, wind southeast, about 8 miles per hour. Bright day, wind southeast, about 8 miles per hour; water 3 feet deep; temperature 82° F.

Plants noted: A large sedge, *Scirpus*, *Pontederia*, *Vallisneria*; *Polygonum*, *Nymphaea americana*, *Castalia odorata*, *Potamogeton* (6 species: *crispus*, *natans*, 2 slender leaved species, 1 fine leaved species, 1 broad leaved species), *Nitella*, *Elodea* and *Phyllotria*.

NAME	No. 1	No. 2
<i>Cyclops leuckarti</i> Claus.....	X	X
<i>Cyclops parvus</i> Herrick.....	X	X
<i>Sida crystallina</i> (O. F. Müller).....	X	X
<i>Diaphanosoma brachyurum</i> (Lieven).....	X	X
<i>Daphnia arcuata</i> (?) Forbes.....	X	.....
<i>Daphnia longispina hyalina</i> (forma) Leydig.....		X
<i>Ceriodaphnia lacustris</i> Birge.....	X	X
<i>Bosmina obtusirostris</i> Sars.....	X	X
<i>Eurycercus lamellatus</i> (O. F. Müller).....	X	X
<i>Alona rectangula</i> Sars.....	X	.....
<i>Chydorus gibbus</i> Lilljeborg.....	X	X
<i>Chydorus sphaericus</i> (O. F. Müller).....	X	X
<i>Alonella rostrata</i> (Koch).....		X
<i>Leptodora kindtii</i> (Focke).....		X
Ostracods.....		X
Species determined.....	11	12
Total species determined.....		14

Collected off Norcross Point, July 21, 1916.

No. 1, one-half mile off Norcross Point, over a depth of 15 to 20 feet; 88 quarts of water were dipped with a tin pail and strained through No. 10 silk bolting cloth net. This was done after dark.

No. 2, just off shore of Norcross Point, after dark, among the weeds; a dip of 44 quarts was poured through a No. 10 bolting cloth net. The bottom here is stony, the depth 18 inches.

No. 3, similar, except taken where there are no weeds.

The numbers represent the density of the surface population of Entomostraca under the conditions then present.

NAME	No. 1	No. cub. ft. at surface	No. 2	No. cub. ft. at surface	No. 3	No. cub. ft. at surface
<i>Epischura lacustris</i> Forbes.	x	9.3	x	0.6	.....	0.0
<i>Diaptomus oregonensis</i> Lilljeborg.	x	.6	.....	.....	.....	.....
<i>Diaptomus minutus</i> Lilljeborg.	x	96.3	x	0.6	.....	0.0
<i>Cyclops leuckarti</i> Claus.	x	17.6	x	2.0	.....	0.0
<i>Cyclops parvus</i> Herrick.	x	.6	x	14.6	x	30.0
<i>Cyclops viridis brevispinosus</i> Her- rick.	x	7.6	.....	.....	.....	.....
<i>Cyclops serrulatus</i> Fischer. ....	.....	.....	x	0.6	.....	0.0
<i>Sida crystallina</i> (O. F. Müller).	x	46.3	x	5.3	x	6.6
<i>Diaphanosoma brachyurum</i> (Lieven)	x	9.0	x	2.6	x	0.6
<i>Daphnia retrocurva</i> Forbes.	x	2.6	.....	.....	.....	.....
<i>Daphnia longispina hyalina</i> (forma) Leydig.	x	6.3	x	1.3	.....	0.0
<i>Bosmina obtusirostris</i> Sars. ....	.....	.....	.....	0.0	x	1.3
<i>Leydigia quadrangularis</i> (Leydig). ..	x	.3	.....	.....	.....	.....
<i>Alona quadrangularis</i> (O. F. Müller)	x	.3	.....	.....	.....	.....
<i>Alona rectangula</i> Sars.	x	.3	x	0.6	x	1.3
<i>Pleuroxus denticulatus</i> Birge. ....	.....	.....	x	0.6	.....	0.0
<i>Chydorus gibbus</i> Lilljeborg. ....	.....	.....	x	0.6	.....	0.0
<i>Leptodora kindtii</i> (Focke).	x	3.6	x	1.3	.....	0.0
Ostracods, mostly <i>Cypridopsis vidua</i> (O. F. Müller). ....	.....	.....	x	23.3	x	72.6
Total Entomostraca.	x	200.7	x	54.0	x	112.4
Amphipods. ....	.....	.....	.....	.....	x	5.3
Hydrachnids. ....	.....	.....	.....	.....	x	7.3

The significance of this microscopic population of plants and animals for fish culture has been the basis for many elaborate investigations. It is definitely known that micro-organisms, both plants and animals, are eaten by the small animals, including young fishes, many of which are largely dependent upon such food. The larger or gross vegetation, which abounds in the shallow waters of the lake, and even the large algae, are eaten by very few fishes, the Carp being the main herbivorous fish in these waters.

In concluding his notes Mr. Doolittle adds, on the basis of his general studies of the food of young fish:

"In rivers and streams, diatoms and other material gathered from the bottom mud, enters largely into the first food of the river and stream fish. A thousand or more of young fish, taken from lakes, belonging to upwards of a score of species, had eaten Entomostraca exclusively for their first food. The entomostracan diet continued as the almost exclusive diet for most of the species until collections ceased in the fall. Pickerel (*Esox reticulatus*) is one of the species which begins to change its diet and take insect food in August."

The Fish Habitats of the Lake and their Fishes. In a relatively shallow lake such as Oneida, the variety of fish habitats is limited. Baker's ('18) studies showed that about 88% of the macroscopic fish food in Lower South Bay

was found within the six foot contour. It follows, therefore, that the shallow waters are the feeding and breeding grounds of most of the fish, and the main habitats at least for young fish. Those that breed in streams, such as the suckers, the Pike Perch, and probably the Ling, soon find their way into the lake, and in the fall the suckers are found in great numbers in the shallow waters. These shallow waters also have the most varied conditions, because here are found the greatest changes in temperature and in light, the greatest variety of vegetation, and the greatest movement and changes in amount of sediment. This is the zone of wave action, the region of fluctuating water level and of greatest topographic diversity. In the deeper waters the influence of currents and waves are less pronounced, and in general conditions are calmer and more uniform. The borders of the islands and submerged reefs or shoals tend to develop conditions similar to those along the shore. The vegetation is most abundant in water from 2 to 4 feet deep (Baker, '18, p. 53).

Provisionally we may thus divide the major fish habitats and associated fish communities into the following:

1. *Shallow Water Habitat and Association.* This includes the water zone above the approximate 6 foot contour, the sandy beaches and exposed headlands, as well as the region of the most abundant growth of emergent and submerged water plants and of the greatest abundance of fish food, as pointed out by Baker. This is the principal feeding and breeding ground for the majority of the fishes. Within this habitat and association there are several minor habitats and fish communities, depending on the topography, exposure, vegetation and the character of the substratum.

The characteristic fish of this habitat are: Tullibee, Blunt-nosed Minnow, Emerald Minnow, Trout Perch, Brook Silversides, Rock Bass (young), Large-mouthed Black Bass (young), Manitou Darter, Tessellated Darter, Miller's Thumb, Spot-tailed Minnow, Silverfin Minnow, Rosy-faced Minnow, Common Sucker (young), Barred Killifish, Pike Perch (young), Perch (young), Eel, Silvery Minnow, Golden Shiner, Cayuga Minnow, Carp, Chub-sucker, Yellow Bullhead (young), Common Bullhead (young), Stonecat, Mud Minnow, Brook Stickleback, Chain Pickerel, Common Sunfish (young), Bridled Minnow and Common Pike.

2. *Deeper Littoral Habitat and Association.* This includes the deeper shore zone between the depths of about 6 and 15 feet. It is the region of the declining gross submerged vegetation with increasing darkness, but often with the persistence of the bulrush *Scirpus*. Physical diversities have declined with depth. There is slight differentiation within this habitat and in its local communities.

The characteristic fish are: Lake Lamprey, Eel (young), Carp, Yellow Bullhead, Common Bullhead, Chain Pickerel, Common Pike, Rock Bass, Common Sunfish, Large-mouthed Black Bass, Small-mouthed Black Bass, Pike Perch, Perch, Striped Bass (young), Tullibee (breeding), and Burbot or Ling (young).

3. *The Deep Water Habitat and Association.* This includes the remainder of the lake below the Deeper Littoral, from the depth of about 15 feet to the bottom at about 55 feet. This is the coolest, darkest, and most uniform habitat.

The characteristic fish are: Lake Lamprey, Tullibee, Common Sucker, *Esox*, Large-mouthed Black Bass, Small-mouthed Black Bass, Pike Perch, Perch, Striped Bass and Burbot (adult).

THE ECONOMIC AND SOCIAL VALUE OF ONEIDA LAKE FISHES

By CHARLES C. ADAMS

The General Situation. Although Oneida Lake is within about eleven miles of Syracuse, the fourth city in size in the State, with a population of about 180,000, its relatively unattractive, low, swampy shores, and its poor transportation facilities, despite several very fine sandy bathing beaches, have attracted comparatively little attention from the public until the last few years. The electric trolleys were a distinct agency for a time, but more recently the automobile and improved highways are the main factors which have stimulated public interest in this lake. Fishing, bathing and the delights of summer cottages situated on suitable parts of the shore seem to have been the chief attractive features.

Relatively very little has been published on the fish and fisheries of this lake. The State has maintained a hatchery at Constantia, on the north shore, for many years and the annual reports of this hatchery contained, during Dr. T. Bean's administration, numerous valuable notes on the fishes of the lake. The old settlers tell a number of interesting stories about the wholesale catch of breeding fish of this lake on their spawning beds, in the early days. This was true particularly of Pike Perch, in the lower part of the inflowing Chittenango Creek, where the fish are reported to have been taken by the wagon load, salted and packed or used merely as fertilizer.

There has been a prolonged struggle between the conflicting fishing interests of the commercial fishermen and the sportsmen. The sportsmen are in the majority and are organized; the market fishermen, although in the minority, are apparently strengthened by commercial interests which have a demand for cheap fish.

For many years the State hatchery at Constantia hatched Oneida Lake Tullibee or Whitefish. This is a valuable food fish which thrives in these waters, does not compete seriously with other species, and its culture should be encouraged; but until some practical and legal method of netting this species, as well as other "cull fish" such as carp, ling, sucker, etc., has been devised (cf. Adams, '26, p. 529), the present rather anomalous situation with regard to this fish will continue. The situation at Oneida Lake has been summarized elsewhere (Adams, '26, p. 522) as follows: "At present, in too many parts of the United States the inland fishing industry is in almost a state of war with the State officials. The sporting interests are often well organized and secure legislation favorable to their interests and they are not always fair to the food aspect of the problem. There are strong, well financed commercial interests which are well organized, which do not fully recognize the sporting interests or appreciate conservation methods, but there are very few corresponding organizations of consumers interested in good and cheap food fish. In some regions the sporting interests are by far the most valuable, in others the food interests predominate. In order to secure the best possible sport fishing, there has been a tendency to make so many restrictive measures that the food industry does not have a reasonable chance; in fact, there has been an unwillingness manifested even to permit the use of so-called cull or rough fish. Prejudices are usually rampant in discussions of these questions, and a fair understanding is very difficult and often seemingly impossible to secure. When fish abound in waters and the prices are attractive naturally illegal fishing by 'pirates' is strongly

stimulated. Some of the more intelligent of these men often insist that the laws are not fair; and not being fair, they have no respect for them. They consider the officials as working for pay to catch them in illegal acts and look upon the whole thing merely as a game of wits, to catch and to escape capture. When fishermen are not permitted to take fish of species which are not sought after by the sportsmen, as is the case with rough and cull fish, they feel the injustice the more keenly, and believe that they are morally justified in this warfare. If, however, there could be established a fair division of the field, some degree of harmony might be developed, but at present neither party trusts or respects the other. At present also the general public, which should be interested in both sides of the controversy, since its interests are paramount, has learned to get along without its fair share of food and game fish. Surely this is not a permanent condition. The aim should be to work toward a fair and technical, rather than 'political' control of all these interests."

Angling at Oneida Lake. Adams and Hankinson ('16) make the following statements in regard to angling in Oneida Lake: "It is seldom that a large inland city is located so close to a large lake abounding in game fish. The exceptional opportunities about Syracuse for anglers are much appreciated, as is shown by the large number of persons who belong to angling organizations. The oldest and largest organization, the Anglers' Association of Onondaga, has over 600 active members. An active younger Society is the 'Central City Sportsmens' Association.' The first named has not only planted millions of fish, received from the Federal and State authorities, but has recently, in co-operation with the State College of Forestry, established a fish nursery at the College Experiment Station at Syracuse for rearing young fish to a favorable planting age. [This has in recent years been abandoned.] These facts are indicative of the character and amount of interest shown in the game fish.

"If one attempts to summarize approved methods of angling in Oneida Lake, much divergence of opinion is found. The number of 'best methods' is amazing. It calls to mind the difficulties encountered in any effort to determine the 'best' in politics, automobiles, etc., because of the diverse personal preferences. As representative opinion, the following has been prepared, on request, by Mr. A. L. Bishop, President of the Anglers' Association of Onondaga, who states that: 'The Oneida Lake game fish may be rated as follows in the order of their preference as game fish: Small-mouthed Black Bass, Pike Perch, Large-mouthed Black Bass, Yellow Perch, Pickerel and Bullheads. An approved method for angling for Pike Perch is to troll the bottom with a small spoon, attached by a copper wire leader 10-12 feet long; in June on stony bottom of moderate depth, in July in deeper water. Bass to be taken by still fishing, with live bait (crawfish, locally known as 'crabs,' and minnows), or with wooden bait with casting rod. Perch are taken by still fishing, live bait (minnows, 'crabs,' or worms) fish eyes, or scarlet ventral fin of the perch. Pickerel are largely taken with a large trolling spoon (larger than for Pike Perch), to a much less degree by still fishing, with minnows. Bullheads are taken at night with worm'."

Without a knowledge of Mr. Bishop's preceding section, Mr. W. H. Weston, Division Chief Game Protector of the State Conservation Commission, has prepared the following statement, using information from a number of his wardens:

"Approved Methods for Angling on Oneida Lake are:

1. Pike Perch. Trolling spoon; bait, minnows; still fishing in shallow bouldery bars early in the season, later, in July and August, in deep water, with worms.
2. Small-mouthed Black Bass. A fish of uncertain habits in taking bait; crawfish or 'crabs,' minnows, worms, grasshoppers, and crickets are recommended. A trolling spoon, hauled very rapidly over bars in shallow waters without a sinker and with cotton line gives good results. At times fly fishing is successful.
3. Pickerel. Trolling; bait casting with frog, minnow or wooden bait, at the surface or below it, is approved.
4. Large-mouthed Black Bass. Same methods as for Pickerel.
5. Yellow Perch. Still fishing, with bait of worms, small minnows, pieces of perch with skin removed, perch eyes, reddish ventral fin of perch, and by fly fishing.
6. Pumpkinseed. Still fishing with worms, or fly fishing.
7. Rock Bass by trolling spoon, or line baited with small minnows or 'crabs.'
8. Bullheads. Line fishing with worms, crab 'tails,' minnows (dead or alive). June the best month for fishing."

In the accompanying Annotated List angling methods are discussed for each species.

It should be emphasized that if angling is to be preserved as a successful sport in this lake, the best breeding grounds must be carefully protected from pollution; likewise the fish on them during the breeding season must be protected from anglers and others. Special attention is directed, beyond, to the importance of the Pike Perch breeding grounds in the lower part of Chittenango Creek, beginning about three miles above Bridgeport (W. H. Weston).

A group of far-sighted Syracuse anglers led by Mr. George Friend have advocated the establishment of a State fish and game sanctuary or preserve to include this lower part of Chittenango Creek, in order to protect the Pike Perch and to have a field base for the protective and fish cultural work on the lake. Both purposes are important. Constant watchfulness is necessary also to prevent pollution of the stream, as are sufficient protectors to patrol the preserve, and to enforce the laws fearlessly. Fish Creek, as well as other important inflowing streams, needs similar consideration if the fisheries of the lake are to be maintained to capacity. There is already some protection on the hatchery grounds at Constantia, but a larger area is needed. It would indeed be folly to attempt to put into practice any sane comprehensive policy for these waters if such important considerations are neglected.

Cobb in 1904 remarked ('05, p. 227) concerning the current State policy for the inland waters, including Oneida Lake, that "the principal aim of the authorities has been, as far as possible, to confine the fishing in the interior lakes and streams to sportsmen, who are attracted, not only from all parts of New York, but from other States and even from foreign lands by the excellent fishing afforded in these waters. Such pleasure seekers are usually liberal and the sums expended by them net a larger profit to the community than would be obtained by the unrestricted use of fishing apparatus on the part of local fishermen. It has been estimated that the sportsmen leave behind them, in the hands of the railroads, hotels, guides, boatmen, etc., several million dollars each year."

The Fisheries of Oneida Lake. "The large amount of animal food produced by the lake and taken in that vicinity is a subject not generally appreciated even locally. The eels and frogs easily lead in importance. At our request the food fish of the lake itself has been rated by Mr. Hiram N. Coville, a former fish dealer living at Brewerton, situated at the outlet of the lake, in the following order of importance:

1. Eels.
2. Pike Perch, Yellow Perch, Bullheads and Pickerel.
3. Pumpkinseed, Black and Red-fin Suckers.
4. Rock Bass.
5. Catfish (*Ictalurus*).
6. Oneida Lake Whitefish or Tullibee.

"The Tullibee or Oneida Lake Whitefish is sold fresh or salted. For salting they are opened along the back, salted to draw the blood, then packed in dry salt. In this manner 400 to 500 pounds are salted each year of the four to five tons of whitefish handled. Pike Perch and Yellow Perch are taken by 'tipups' through the ice. Small minnows are used for bait for Perch in this ice fishing.

"At the State hatchery at Constantia special attention is given to Pike Perch, Small-mouthed Black Bass, Yellow Perch and Oneida Lake Whitefish or Tullibee." (Since this was written, Tullibee hatching has been discontinued by the Constantia hatchery.)

Eel Industry. "We are indebted to Mr. C. F. Davison and Mr. H. N. Coville for the following items concerning their fish business. Eels are taken in various parts of the lake, but the main catch is made at Caughdenoy, four miles down the Oneida River, just below the large dam, which controls the level of Oneida Lake. Here there are two rows of weirs, each consisting of three traps or pots." (Adams and Hankinson, '16.) Further discussion of the Eel industry will be found elsewhere in the body of the report.

Economic Value of the Fish. On account of the favorable conditions for the production of food, this shallow lake is, as has been shown, capable of producing a vast amount of fish, both for sport and for food. The most important food fishes are Tullibee, Perch, Carp, Sunfish, Bullheads, Ling, Eels, Suckers, and Chain Pickerel and Common Pike. Pike Perch and the Large-mouthed and the Small-mouthed Black Bass are usually classed as game fish. That all of these fishes are not equally appreciated as food does not justify us in neglecting their consideration in a fish cultural policy.

The economic importance of the fisheries of the lake has never received much attention. Some preliminary statistical studies of New York waters, including Oneida Lake, were made in 1896 and in 1903, by Cobb ('05), for the U. S. Fish Commission. At this time Cobb stated (pp. 227-228) that, "Whenever possible without injury to the sport fishing, the State has permitted the use of nets to some extent, principally for the purpose of reducing the abundance of the commoner species of fishes, which, when in excessive numbers, do serious damage to the game fish by devouring spawn and fry. It has been an exceedingly difficult matter to guard waters so extensive, however, and as a result there is much illegal fishing. During 1901 the authorities seized 803 fyke nets, 433 trap nets, 416 gill nets, 76 squat nets, 20 seines, 335 set lines, 7 spears, 16 eel weirs, 8 wire nets, and 2,637

tip-ups. The total number of illegal devices destroyed was 4,761, representing a total money value of \$25,820, a sum greater than the whole investment in the legal commercial fisheries of the entire region.

"The greatest drawback to the fisheries of many of the lakes and streams is the presence of undesirable species. The alewife in Seneca Lake, the gar in Lake Chautauqua, and the ling in most of the lakes and rivers, are very unpopular residents, and unless their numbers are reduced shortly they will do considerable harm. The fishes appear to be useless, although the ling has been prepared as cod in Buffalo. The German Carp is also regarded with some disfavor, but if taken in the winter time and sent alive to New York City would net the shipper a fair price, since it is a very hardy fish and would stand transportation in ice." Regarding Oneida Lake he states (p. 233), "The principal fishing towns on the shore are Brewerton, at the outlet, Constantia and Cleveland on the north side, and Cicero Center, Bridgeport and South Bay on the south side of the lake. Trap nets were in use at the time of the statistical canvass made by the U. S. Fish Commission in 1895, the common fish having become so plentiful as to interfere seriously with the game fishing. The use of these nets was prohibited after the 1896 season had passed, however. In 1902 close to and in the outlet 7 seines were operated for black (Common) suckers, which come into the lake from Oneida River in countless numbers in the spring, and these operations were considered a great benefit to the other fisheries, as the suckers are said to consume great quantities of the spawn of other species. Set lines, hand lines, and tip-ups were also used." And (p. 234) further, "Oneida Lake is full of the commoner species of fishes, such as ling, suckers, pumpkinseeds, rock bass, etc., which greatly interfere with the game fishing, and it would benefit the sportsmen, with whom this lake is a favorite resort, could some means be devised for decreasing the number of objectionable species. The use of trap nets for a season or two would probably accomplish the purpose." Cobb also refers to the catch of Eels on the Oneida River at Caughdenoy.

It is very doubtful if any large body of water in the State is capable of producing, per square mile, more fish annually than Oneida Lake. Without doubt its output is relatively much greater than that for Lakes Erie or Ontario. In a recent summary of the relative productivity of lakes (Adams, '26, pp. 537-540), are given calculations indicating that the fisheries of the Great Lakes produce roughly 1,000 pounds of fish per square mile. The Whitefish of Canadian Lake Erie has been calculated to produce nearly 600 pounds per square mile. Pond culture in America has produced as much as 100 pounds per acre, which for the square mile would give 64,000 pounds. Evidently Oneida Lake stands in an intermediate position, and therefore the following calculations are of interest.

Table for Calculating Productivity

80 square miles or 51,200 acres in Oneida Lake.	
67 square miles or 42,880 acres, over 12 feet in depth.	
13 square miles or 8,320 acres, less than 12 feet in depth.	
8,320 acres at 50 pounds per acre	416,000 pounds, or 208 tons.
8,320 acres at 100 pounds per acre	832,000 pounds, or 416 tons.
8,320 acres at 150 pounds per acre	1,248,000 pounds, or 624 tons.
42,880 acres at 10 pounds per acre	428,800 pounds, or 214.4 tons.
42,880 acres at 25 pounds per acre	1,072,000 pounds, or 536 tons.

Of the 80 square miles (or 51,200 acres) of Oneida Lake, about 13 square miles are less than 12 feet deep. This area amounts to 8,320 acres, which if it produced 50 pounds per acre annually, would give 416,000 pounds or 208 tons of fish; if it produced 100 pounds per acre it would total 832,000 pounds of fish, or 416 tons. If the remainder of the lake only produced 10 pounds per acre annually for its 42,880 acres, it would give 214.4 tons. If to this last amount we add the estimate of 208 tons for the 8,320 acres under 12 feet in depth, the total for the lake is 844,800 pounds or roughly over 422 tons of fish. This is probably a very conservative estimate because, in 1902, Cobb (p. 239) reported the commercial capture of 616,900 pounds of suckers from Oneida Lake, taken with seines, and the total for all fish was over 700,000 pounds. This total did not include the Tullibee or the Oneida River Eels. This means over 300 tons of suckers alone. Possibly we may calculate 13 square miles at 100 pounds per acre, and 67 square miles at 25 pounds, or a total of 416 tons and 536 tons, respectively, for the two depth areas. This would give a total of 952 tons annually, or about 2.6 tons for each day in the year. Such estimates, however rough and inexact they must necessarily be, serve at least to show that we are here dealing with a resource of considerable magnitude and one certainly worthy of thoughtful consideration.

After preparing the preceding estimates a request was made of Mr. C. F. Davison, of Brewerton, the best informed fish dealer on the lake, for his opinion on these matters. His son, Mr. S. F. Davison, sent their estimates for the entire lake as follows:—

“The annual catch of fish from Oneida Lake is very difficult to estimate as we have no accurate means of knowing. But we believe that the catch amounts to 250–300 tons, not including about 50 tons of carp recently taken. This gives 300–350 tons annually. Of course you understand that this is just a guess but we believe that the above is a conservative estimate. We believe that this total would be about 50% game fish (Pike, Pickerel and Bass). We are estimating everything, the summer hook and line, the ice fishing, as well as the illegal net fishing.” Dated March 20, 1928. In response to a later request they add the following:—

“You write that in 1902 the sucker catch amounted to about 617,000 pounds. It must be remembered that this was under license from the State and was carried on extensively. When the barge canal was put through it ruined the sucker grounds at this end of the lake and consequently this stopped the business of hauling the seine for suckers. It is our opinion that the sucker catch at that time would amount to or equal the entire catch of fish (both game and otherwise) at the present time. Under present conditions we do not believe that the catch would amount to over one ton daily. However we believe that under a license from the State this total would be increased to two or three tons daily without greatly diminishing the fish life in the lake. We are assuming that the State would only license the taking of the cull fish, returning the game fish to the water with as little injury as possible.” Dated April 24, 1928.

A General Policy. The shallow, warm water of Oneida Lake with its abundance of vegetation and fish food makes it an unusually suitable and important

lake for producing both game and food fishes. It seems unlikely that the existing physical or biotic conditions in the lake will be disturbed to any great extent by man; hence at least for the present both kinds of fishes should be given a chance.

A policy for the future development of the fish culture of this lake should include the following features:

1. Continued investigation of the waters by resident naturalists, as it is only by prolonged study that its fisheries problems can be properly solved and a sound policy of its management developed and maintained.

2. A constructive and efficient policy is needed for the State hatchery at Constantia, and for its plantings in the lake. As Dr. Kendall ('24, p. 337) remarks: "Too often fish hatcheries, as commonly conducted, have depleted the local stock of breeding fishes in their immediate vicinity, in order to stock other remote waters. As the customary planting methods are so frequently unsatisfactory this waste has tended to spread depletion *radially* from the hatcheries." (Cf. also Adams, '25, pp. 383-385, for an example of this abuse in Yellowstone National Park).

3. To maintain Pike Perch, which is the favorite angling fish, Fish Preserves should be established on the main breeding grounds of the important inflowing streams, and the *pollution* of Chittenango Creek and other creeks must be prevented. It may be necessary to make preserves of certain islands, such as Shackelton Shoals, in order to maintain the Tullibee.

4. The public needs education and demonstration of the value of the Tullibee, Carp, Ling, and possibly other little appreciated kinds of fish, in relation to the fish of the lake as a whole.

5. A *fresh start* should be made by both the angling and commercial food fish interests, to work out some practicable method by which netting of the waters should be conducted, so as to control the excessive increase of the less desirable and over-mature fish, and to make room for the more desirable ones. Both kinds of fishing could be improved by such a plan of co-operation. Possibly a license, under a heavy bond, is the only method that would succeed, if "politics" can be eliminated from law enforcement. Possibly the only solution is "publicity" for the political interference with law enforcement, which is one of the greatest difficulties in all conservation projects. It is only when there is elimination of "political" interference with law enforcement that we can expect piracy to decline. There is too much talk of "catching pirates" and of "law enforcement" that is camouflage for "politics," and such talk diverts attention from the main issue and other important matters, such as fish preserves, the control of "cull fish," the lamprey problem and pollution. It is even possible that a certain amount of "illegal" fishing has been a distinct fish cultural advantage to the lake, when no really intelligent legal method has been practised for harvesting certain abundant kinds of mature fish.

BREEDING HABITS OF ONEIDA LAKE FISHES

By T. L. HANKINSON

Our observations on the breeding habits of the fishes of Oneida Lake were few, because the field work had to be done in late summer when most of the species were through spawning. But considerable information was obtained from

testimony of persons acquainted with local species, and such of this testimony as was in accord with known facts, has been incorporated in this report. In the summer of 1916 we found the following fishes breeding: Blunt-nosed Minnow, Long-eared Sunfish, Common Sunfish and the Tessellated Darters. In April, 1920, I visited Constantia and made observations on the spawning of the Pike Perch.

The literature has been scanned for facts pertaining to the breeding habits and life histories of the different species represented in the lake; and it has been found that there is still much unknown in these important phases of fish study. We found, for example, very few or no published data on the breeding habits of the following: Silvery, Black-chinned, Straw-colored, Gilbert's, Black-nosed, Bridled, Spot-tailed, Silverfin, Emerald and Rosy-faced Minnows; Black-nosed and Long-nosed Dace, Short-headed Redhorse, Variegated Stonecat, Barred Killifish, Black-sided Darter, and Striped Bass. Only a fair amount of information appears to be available on the breeding habits of the following: Alewife, Tullibee, Eel, Golden Shiner, Cut-lips, Chub Sucker, Hog Sucker, Yellow Bullhead, Spotted Catfish, Stonecat, Trout Perch, Mud Minnow, Brook Silversides, Calico Bass, Fan-tailed, Manitou and Iowa Darters and Burbot. The breeding habits and life histories of the following may be considered well known: Lake Lamprey, Bowfin, Atlantic Salmon, Blunt-nosed Minnow, Common Shiner, Horned Dace, Fallfish, Carp, Common Redhorse, Common Sucker, Common Sunfish, Large-mouth and Small-mouth Black Bass, Pike Perch, Perch, Tessellated Darters, and Common Sculpin.

Breeding Conditions. The diversified conditions in Oneida Lake furnish breeding places for many kinds of fish; and this undoubtedly accounts in a large measure for the many species and individuals there found. That suitable breeding places are very important in determining the presence or absence of fish, perhaps more so than is the character of the food present, is the opinion of Reighard ('14, p. 99) who says: "In order that fishes may thrive in any natural water it is necessary that there be sufficient food and that there be available breeding grounds suited to each species. Most fishes are not narrowly limited in their choice of food. They are capable, with few exceptions, of utilizing the available animal food. Their choice of breeding grounds is more limited. Yet in attempting to determine the suitability of a particular water for a given fish, far more attention has been paid to food than to breeding grounds. Of the two factors the latter is probably the more important." Shelford (quoted by Pearse, '18, p. 281) recognizes this importance when he says: "An animal should be associated, first, with breeding conditions; second, with the feeding conditions; third, with conditions furnishing shelter."

Obviously a species of fish must have suitable places to breed as well as to feed, and it must be able to find protection from enemies as well as from other destructive or antagonistic agencies; but the relative values of these are difficult and perhaps impossible to determine, since all are necessary to the life of a fish in a given habitat (Pearse, '18, p. 281).

The abundance of Lake Lampreys, Pike Perch, Common Suckers, Fallfish and Trout Perch in Oneida Lake is undoubtedly due, in large measure, to good

streams for spawning purposes, connected with the lake. The marshy or swampy borders (Figs. 193, 195, 198) favor the multiplication of Carp, Chain Pickerel, Common Pike and Mud Minnows. The extensive submerged beaches and other shallow areas help bring about suitable breeding conditions for at least sixteen species of fish common in the lake. These are: Blunt-nosed and Spot-tailed Minnows, Golden Shiner, Yellow Bullhead, Common Bullhead, Stonecat, Barred Killfish, Brook Silversides, Rock Bass, Common Sunfish, Long-eared Sunfish, Large-mouthed Black Bass, Small-mouthed Black Bass, Manitou Darter, Tessellated Darter and Common Sculpin.

Then too, there are some species abundant in the lake, for which there appear to be no breeding conditions such as have been found most favorable for these species in other localities. For example, the Tessellated Darters are usually found spawning on a bottom containing loose stones to the underside of which they attach their eggs; but the stones in Oneida Lake are usually embedded in the bottom soil, so that the species here probably lays its eggs in other situations. The only eggs of this species we found were on the lower side of a piece of rusted tin, on the bottom of the lake.

Small-mouthed Black Bass likewise are numerous in Oneida Lake, but the gravel bottoms which they seem to prefer for nesting, are scarce. Artificial planting may account for a large number of these fish; or they may at times, perhaps, nest on solid rocky bottoms, or on sandy bottoms (Wright and Allen, '13, p. 6). A few other species also are scarce in the lake, notwithstanding the fact that favorable breeding places appear to be extensive; these are, Bowfin, Calico Bass, and Bluegill.

Certain species found in the Great Lakes and other neighboring waters seem to be entirely absent in the Oneida Lake drainage system, although breeding places of the kind they ordinarily select appear to exist there in abundance. Important among such species are: Lake Sturgeon, *Acipenser fulvescens* Rafinesque; Long-nosed Gar, *Lepisosteus ossesus* Linn.

The breeding habitats in the part of the Oneida Lake drainage system studied are of three main types. These are: (1) Oneida Lake; (2) bordering swamps or marshes; and (3) tributary streams. The lake breeding grounds may be conveniently divided into (a) the shallow-water or shoal area; (b) the intermediate region; and (c) the deep-water region. None of these, obviously, can be accurately defined, but we arbitrarily considered the shallow or shoal area to be that area with water not much deeper than five feet, that is, with a depth not too great for supporting rigid and partly submerged aquatic plants, like rushes, sedges and cat-tails. The deep-water region has a depth greater than ten feet. Between these two, the intermediate region is found. It is here that potamogetons and other wholly or almost wholly submerged aquatic plants thrive best.

The majority of the Oneida Lake fishes evidently prefer the shallow-water area for breeding, but little information is at hand to show the extent to which the other areas are used. Tullibees spawn in the intermediate region, according to data furnished by Mr. J. D. Black, who thinks that in stormy weather they seek the deep water for this purpose. White Bass, Burbot and Perch probably breed principally beyond the shallow-water zone in the lake.

The breeding areas of the shallow-water zone may be divided into those with vegetation and those without vegetation. The former are preferred by most of the breeders, but the Blunt-nosed Minnow, Small-mouthed Black Bass, Manitou Darter and Miller's Thumb appear to be more attracted by rock or gravel than by plants.

The bordering swamp is diversified in character (Figs. 196, 203) but insufficient data with regard to it are at hand to permit subdividing it into possible different breeding habitats. It is probable that the Common Pike and the Chain Pickerel prefer the open marsh to the wooded swamp; and it is evident from testimony that Carp breed in situations of both types (Figs. 193 and 203). Allen ('14, p. 56) notes that Common Suckers breed in marshes about Cayuga Lake, New York.

The small tributary streams are of two general kinds: sluggish ditches, and shallow, rocky, rapid brooks (Fig. 191). The former are probably used by the swamp breeders above mentioned as well as by the Mud Minnows.

Breeding Seasons. From the little that is known of the life histories of Oneida Lake fishes, it appears that the time of greatest breeding activity is during May and June. Four common species are known to begin breeding in March or possibly earlier. These are: Mud Minnow, Chain Pickerel, Common Pike, and Perch. These four belong distinctly to the *warming water* group of breeders (Gurley, '02, p. 410). Only two fishes common in the region require *cooling water* for the initiation of spawning activities. These are the Tullibee, which breeds in fall, and the Burbot which has a very long breeding season, lasting apparently from fall and until the water begins to warm up in the spring.

Breeding Activities. The principal breeding activities of Oneida Lake fishes consist of the following: (a) migration, (b) nest-building, (c) spawning, (d) care of eggs, and (e) care of young. The common species in the drainage system which are known to perform marked migratory movements are: Lake Lamprey, Eel, Common Sucker, Common Redhorse, Short-headed Redhorse, Mud Minnow and Pike Perch. These, with exception of the Eel, are all known to run from lakes to streams, where they spawn. The Eel uses streams as highways to the sea where it breeds, and its long, down-stream migrations are probably in all cases to be looked upon as efforts to reach breeding places in the ocean. In addition to their streamward movements, many fishes in the lake have shorter, less definite migrations from deep to shallow water. This is exhibited distinctly by such common forms as Tullibee, Carp, Bullhead, Chain Pickerel, Common Pike, Sunfish, Black Bass, Perch, and Pike Perch. The fishes that go to shallow water and to streams to spawn are very probably influenced by temperature changes. Gurley ('02, p. 418) says of this habit: "Although we are not here directly concerned with the origin of the seek-the-beach impulse, that impulse being taken as our point of departure, it may be pointed out, parenthetically, that it is as certainly temperature-induced as its derivative, the anadromous habit."

Some species, all of them small, appear to dwell principally in the shallow-water area of lakes or streams and to avoid greater depths (attention was not given in this survey to the nocturnal distribution of small fishes in Oneida Lake,

which very likely is quite different from that noted during the daytime). They thus seem to lack definite breeding season migrations. But such an apparent limitation of habitat may be merely an impression due to our paucity of information on the movements of small fishes. They leave the shore region at times, apparently when temperature, wind, or other factors such as presence of enemies, produce unfavorable conditions for them in the marginal shallows, but to what depth they retire does not appear to be known. Examples of such species common in the Oneida region, are: Silvery, Blunt-nosed, Bridled, Spot-tailed, Silverfin, Emerald and Rosy-faced Minnows; Barred Killifish, Trout Perch, Manitou, Tessellated and Iowa Darters, Common Sculpin, and the young of Perch, Golden Shiner, Black Bass, Sunfish and Rock Bass. On the sandy beach at the east end of the lake the rapidly receding water, after a period of strong west wind, leaves many of these small, shore visiting species stranded in temporary pools (Figs. 216-218). On September 9, 1927, Mr. Dence, Dr. Johnson and Prof. Hankinson found many fishes thus marooned in shallow ponds of the sandy beach along the northeast shore of the lake. Here were large numbers of young Perch, and many young Black Bass of both species; also a few Rock Bass and Striped Bass, with many of the minnows and other shore fish.

Fifteen species of fish found in Oneida Lake are known to make nests either in the lake or in its tributary streams; nests being here considered to be modifications of environmental features of various kinds, as vegetation, bottom or other material. These nest builders are: Lake Lamprey, Bowfin, Fallfish, Horned Dace, Cut-lips, Common Bullhead, Yellow Bullhead, Small- and Large-mouthed Black Basses, Bluegill, Common and Long-eared Sunfishes, Rock Bass, Calico Bass, and Brook Stickleback. The Blunt-nosed Minnow and the Tessellated and Fan-tailed Darters place their eggs on the flat lower surfaces of stones, so that it scarcely can be said that they make nests. Some fishes make rather large, often conspicuous, nests in the form of symmetrical depressions, or they may simply be bottom areas cleared of fine soil, slime, or vegetation. Nests of this type are made by Lake Lamprey, Bowfin, Bullheads, Sunfish and Black Bass. The Horned Dace, and the Cut-lips carry small stones into a pile on which they deposit their eggs. Bullheads sometimes construct burrows. The Brook Stickleback is said to build a nest out of vegetation (Barker, '18; Wright and Allen, '13, p. 5; Forbes and Richardson, '09, p. 223).

All Oneida Lake fishes of known habits spawn in the way usual among fishes. A male (one or more) approximates a female closely or places himself in contact with her, and as the eggs are laid the milt is discharged in such a way as to insure fertilization. In the case of Lake Lamprey, Bowfin, Blunt-nosed Minnow, Horned Dace, Fallfish, Common Pike, Rock Bass, Long-eared Sunfish, Common Sunfish, both black basses and the Tessellated Darter, only one male is present during the spawning act. Ordinarily the female approaches the male and the spawning act may be repeated by the same female or the male may join a different female. In other cases, one female is accompanied by a number of males. This is the case with the Carp and the Suckers (Reighard, '20), and it probably is usual with the Tullibee and the Pike Perch. In the spawning of the Manitou and Iowa Darters and the Common Shiner, a group of males is accompanied by a

group of females. Now and then there is a partial mixing of the two groups, with a coupling of males and females.

Of the nesting-fishes found in the lake, the following guard their eggs after they are laid: Bowfin, Blunt-nosed Minnow, and the bullheads; all of the centrarchids, and the Tessellated and the Fantail Darters. The male serves as guard. The only evidence found of the female guarding the eggs is that given by Stranahan in the case of the Common Bullhead (Kendall, '10, p. 29). The attending fish are usually bold and drive away or attack other aquatic animals nearing their nests. Sunfish and bass frequently strike a person's hand if it is lowered in the water near the nest; but there are varying degrees of boldness among individuals of a species as well as among different species. Hankinson has found Bluegills very shy and inclined to leave their nests at slight indications of danger; and he has noted this also to be the case with some Large-mouthed Black Bass. On the other hand, Rock Bass, Common Sunfish and Long-eared Sunfish are very bold and pugnacious when defending their eggs; but also individuals of these species differ markedly in amount of courage displayed. It is somewhat unusual for fishes to care for their young. In the case of five species found in Oneida Lake parents are known to accompany their young after they leave the nest. These are, Bowfin, Yellow Bullhead, Common Bullhead and the two black basses. Ordinarily parental duties cease with the spawning act or with the hatching of the eggs.

Food does not appear to be taken to any extent by fishes during their breeding activities, yet considerable more information is needed for definite conclusions on this point. It is probable that fishes generally take an unusual amount of food just prior to the breeding season. This is the case with the Carp, according to Seeley ('86, p. 97)—who notes that it is like many other fishes in this respect,—and with the Lake Lamprey (Surface, '99, p. 211). Lake Lampreys on the contrary cease feeding just before the breeding season, and their alimentary canals atrophy. It is not likely that they resume feeding at the close of the breeding season (Gage, '93, p. 439). Pearse ('18, p. 281) remarks that most fishes cease or restrict their feeding during the breeding season.

Little information can be found on the extent to which fishes feed while guarding eggs or young. The Common Bullhead is known to draw its eggs or young into its mouth and eject them again, but these are sometimes swallowed (Kendall, '03, p. 408). Smith and Harron ('04, p. 154) in making aquarium observations on breeding Bullheads fed them liver and beef. They say: "At no time did their appetites fail. There was apparently no interference with deglutition, or closure of the œsophagus, such as has been observed in some other cat-fishes."

Colors and Structures accompanying Breeding. Sexual distinctions are especially noticeable during the breeding season in some of the species of fish found in Oneida Lake. The male Lake Lamprey then develops a dorsal ridge, whereas at other times the sexes can be identified only upon dissection (Gage, '93, p. 427). In the Bowfin the males average smaller than the females, have bright green fins and a conspicuous tail-spot which is black, bordered with orange or yellow. There are also other minor color differences (See Reighard, '03, p. 61). Mr. J. D. Black

says it is easy to distinguish male Tullibees during the spawning time, for then they are smaller and more trim than the females.

The minnows and suckers are peculiar in that the breeding males, with few exceptions, have horny tubercles or pearl organs on the head or other parts of the body (Fowler, '13, p. 471). In the Blunt-nosed Minnow, the Horned Dace and the Fallfish, the tubercles are very prominent and confined to the head. The Chub Sucker has conspicuous pearl organs on the snout, with many small ones on the anal fin and adjacent part of the body. The Common Sucker and the Common Redhorse have anal fin tubercles, but none on the head or the body, except on a small area adjacent to the anal fin. The Common Sucker has pearl organs on the lower half of the caudal fin, in addition to those on the anal. In the following Oneida Lake species the breeding males have fine granules on the head or the back, instead of prominent and rather definitely localized tubercles: Silvery and Gilbert's Minnows, Silverfin, Common Shiner, Rosy-faced Minnow and Black-nosed Dace. The male Golden Shiner has the sides rough with minute tubercles, but has none on the head (Forbes and Richardson, '09, p. 128). According to Hessel ('81, p. 872), the Carp has wart-like protuberances on the head and back; but these were not found by Cole in his extensive studies of this species in the Great Lakes region (Cole, '05, p. 578). The chief use of these pearl organs, in minnows, according to Reighard ('04, p. 211), is to enable the male to hold the female during the spawning act. But in some species they are of use in combats and in nest building.

The males of minnows and suckers are often colored very differently from the female during the breeding season. But such differences are not prominent at other times. The male Blunt-nosed Minnow becomes almost black. In the male Silverfin a white substance is deposited in some of the fins and the body becomes marked with blue and yellow (Forbes and Richardson, '09, p. 145). The male Common Shiner is reddish on the sides and on the fins (l.c., p. 147). Much red develops also in breeding males of the Rosy-faced Minnow, Horned Dace, Long-nosed Dace, and Redhorse; in fact, these males in breeding dress are among the most attractive of our fresh water fishes. In many cases these colors can be seen on fishes in their native waters, but to see the colors well it is an advantage to transfer the fish to an aquarium, although in some cases the colors become decidedly duller after the fish has been caught, or after its sexual excitement has ceased, as Hankinson ('21a, p. 136) has observed with the Common Sucker in Illinois.

The form of the body is sometimes altered in minnows and suckers by the thickening of the tissues of the back, as in the Blunt-nosed Minnow, or of the snout, as in the Silverfin. Male Brook Sticklebacks are also highly pigmented, making them almost the gaudiest of our fresh-water fishes. The males of some darters found in the Eastern United States are exceedingly beautiful little fish, but only one of the highly colored species was taken by us in Oneida Lake, namely, the Iowa Darter (See Forbes and Richardson, '09, p. 306).

Young Fish. Some data were obtained on the habits and habitats of young fish in Oneida Lake, as they occur in shallow water, but very little is known of the

habits and distribution of these same species in deep water. That some of them dwelt there, at least during the times that we fished, was very evident from their absence or scarcity in our many shallow-water collections. We learned that many small fishes live in the deep-water zone, for schools of them, or disturbances in the water caused by them, were frequently seen at the surface here in quiet weather, but we were not able to make collections here, nor could we see them clearly enough for identification. There appears to be little information concerning young fishes in the deep waters of our lakes, and it is important that such collections should be made. In the clear waters of Walnut Lake, Michigan, hundreds of small fish could at times be seen in ten or more feet of water, which appeared to be of the same kinds that ordinarily were found along the shores. Young Perch were seen several hundred feet from shore, swimming at the surface in over forty feet of water (Hankinson, '08, p. 206, 215); and a *Notropis volucellus* (then called *Notropis bleunius*) was caught in 20 to 30 feet of water in this lake. Hubbs ('21, p. 263) found young of Brook Silversides living entirely over the deep water zone of Portage Lake in Michigan.

With the facts obtainable concerning the distribution and movements of young fishes in Oneida Lake, we find:

(1) Young fish living on or near the shallow-water breeding grounds of their parents.

(2) Young that move from the shallow-water breeding areas to deep water soon after they are hatched.

(3) Young that move to shallow areas from the deeper water where the adults breed.

(4) Young fishes hatching in deep water and remaining there.

(5) Young on lake shallows, which are of species breeding in streams.

(6) Young remaining in streams where they were hatched—true stream fish.

No. 1 includes many individuals of the following: Blunt-nosed Minnow, Golden Shiner, Carp, Yellow Bullhead, Common Bullhead, Stonecat, Mud Minnow, Barred Killifish, Chain Pickerel, Rock Bass, Calico Bass, Common Sunfish, both black basses, Zebra, Tessellated and Fan-tailed Darters, and the Common Sculpin. There appears to be little migration by these fishes, aside from congregations at certain feeding grounds such as patches of aquatic vegetation, or retirement to deep water with the appearance of adverse conditions in shallow areas.

No. 2 very probably includes Brook Silversides, and possibly some young Tullibees.

The Perch furnishes an example of No. 3, as does very probably the Burbot also.

No. 4 probably includes young of Tullibees.

No. 5 includes many individuals of each of the following: Fallfish, Long-nosed Dace, Cut-lips, Common Sucker, Trout Perch, Pike Perch.

No. 6 includes the following: Lake Lamprey, Common Shiner, and Black-nosed Dace.

Enemies. The reproductive activities of fishes are frequently interfered with by enemies. The eggs of spawning lampreys, Carp, suckers, minnows, darters,

bass and sunfish are known to be eaten by small fishes, principally minnows; and undoubtedly the eggs of other fishes also are devoured at times by these little predators. At Walnut Lake, Michigan, Hankinson ('08, p. 204) found Blunt-nosed Minnows important as egg-eaters, and Bensley ('15, p. 22), writing of the Blunt-nosed Minnows, says: "During the nesting season of the black and rock bass, they are commonly seen in large numbers waiting about the nests. If the latter are left for a moment the contents are quickly disposed of." Reighard ('03, p. 80) found Common Sunfish apparently feeding on the eggs of the Bowfin. Kendall ('03, p. 405) found the Common Bullhead and another catfish at one time feeding almost exclusively upon spawn of herring (*Pomolobus*), and to such an extent that their stomachs were distended with the eggs. Reighard notes ('10, p. 1133) that the eggs of Horned Dace are probably eaten by suckers and by some minnows that root in loose gravel when feeding. Ellis and Roe ('17, p. 69) saw Common Suckers eating eggs of Log-Perch (*Percina caprodes*); and Bensley ('15, p. 17) tells of Common Suckers entering the nests of Rock Bass and Black Bass and eating the eggs, meeting with little resistance from the occupants of the nests. Nesting fish in shallow water are subject to unusual dangers, although these are lessened somewhat by the protective markings of breeding fish, which often develop in the males, especially. Reighard ('02, p. 574) describes such markings for the Bowfin. Ignorant or selfish fishermen sometimes spear or otherwise capture black bass and other valuable fishes on their nests, leaving their eggs thus to be devoured without hindrance by minnows and other predacious species of aquatic animals.

EXPLANATION OF THE SUMMARY TABLE

The table appended herewith gives the most important information that can be gleaned from our data or from the literature on Oneida Lake fish. A brief explanation may first be given:

Breeding Habitat. By this is meant the kind of situation where fish breed. Brooks are considered to be small streams a few feet wide, with stretches of shallow, rapid and dashing water (Fig. 220). Creeks are larger and deeper than brooks and with less rapid water. Douglass Creek (Fig. 221) is a type. Rivers are large and deep, fifty or more feet in width. Chittenango Creek (Figs. 222, 223) is more like a small river than is the type of stream ordinarily called a river, and Fish Creek and Oneida Creek are other examples.

Breeding Conditions. These are conditions in the environment of the fish, which it selects for breeding purposes. By shallow water we mean that depth which gives a distinct view of the bottom when the water is clear. This depth is under five or six feet, and usually the expression "shallow water" refers to water under three feet deep. In regard to small streams the expression usually means a few inches, whereas three feet or more here is "deep" water. Riffles are areas with so little water flowing over stones or other submerged objects that its surface is broken and irregular. A stream-pool is a relatively deep and quiet part of the stream, usually of small area. In the water-temperature column, the plus sign means that breeding takes place in warming water, and the minus sign, in cooling water.

TABLE NO. 5. TABULAR SUMMARY OF BREEDING RELATIONS

	Principal Breeding Habitat	Breeding Conditions	Deposition of Eggs	Probable Breeding Season
	Ocean — salt water Brooks Creeks Rivers Lakes Ponds Forested Swamp Open swamp or marsh	In or near Riffles Stream pool Rapid current Deep water Rocky bottom Single bottom Gravel bottom Sand bottom Mud bottom Water plants Water temperature	On bottom stones On water plants On unprepared bottom In depression nest In pebble heap nest In nest made of vegetation On boards and tin articles Eggs cared for by parent Young cared for by parent	January February March April May June July August September October November December
Lake Lamprey.....	x	x x	x	x x
Bowfin.....	x x	x	x	
Alewife.....	x x	x	x	
Tullibee.....	x	x	x	
Atlantic Salmon.....	x	x	x	
Common Sucker.....	x x	x x	x	
Hog Sucker.....	x x	x	x	
Chub-sucker.....	x	x	x	
Common Redhorse.....	x x	x x	x	
Short-headed Redhorse.....	x	x	x	
Carp.....	x x	x	x	
Black-nosed Dace.....	x x	x	x	
Long-nosed Dace.....	x	x	x	
Fallfish.....	x x	x	x	
Horned Dace.....	x x	x x	x	
Black-chinned Minnow.....	x	x	x	
Bridled Minnow.....	x	x	x	
Black-nose Minnow.....	x	x	x	
Straw-colored Minnow.....	x	x	x	
Gilbert's Minnow.....	x	x	x	
Spot-tailed Minnow.....	x	x	x	
Silverfin Minnow.....	x	x	x	
Emerald Minnow.....	x	x	x	
Rosy-faced Minnow.....	x	x	x	
Common Shiner.....	x	x	x	
Cut-lips.....	x	x	x	
Golden Shiner.....	x	x	x	
Silvery Minnow.....	x x	x x	x	
Blunt-nosed Minnow.....	x x	x x	x	
Channel Catfish.....	x	x	x	
Common Bullhead.....	x	x	x	
Yellow Bullhead.....	x	x	x	
Stonecat.....	x	x	x	
Variiegated Stonecat.....	x	x	x	
Mud Minnow.....	x	x	x	
Chain Pickerel.....	x	x	x	
Common Pike.....	x	x	x	
Eel.....	x	x	x	
Barred Killifish.....	x	x	x	
Trout Perch.....	x	x	x	
White Bass.....	x	x	x	
Perch.....	x	x	x	
Pike Perch.....	x	x	x	
Black-sided Darter.....	x	x	x	
Manitou Darter.....	x	x	x	
Tessellated Darter.....	x	x	x	
Iowa Darter.....	x	x	x	
Fantail Darter.....	x	x	x	
Small-mouthed Black Bass.....	x	x	x	
Large-mouthed Black Bass.....	x	x	x	
Bluegill.....	x	x	x	
Long-eared Sunfish.....	x	x	x	
Common Sunfish.....	x	x	x	
Rock Bass.....	x	x	x	
Calico Bass.....	x	x	x	
Brook Silversides.....	x	x	x	
Miller's Thumb.....	x	x	x	
Brook Stickleback.....	x	x	x	
Burbot.....	x	x	x	

Deposition of Eggs. This refers to the place where the eggs are laid. Those laid on stones and on water plants and other objects are attached by adhesive coats.

Breeding Season. This is marked by horizontal lines passing through columns for the months in which the fish is known to breed. Scarcity of information on the breeding seasons of our fishes make it evident that the true breeding periods in many cases are much longer than is shown by these lines. This is especially true with the cyprinids and other non-food or non-game fishes, which have received relatively little attention.

IDENTIFICATION OF ONEIDA LAKE FISHES

By T. L. HANKINSON

The terminology used in this account of Oneida Lake fishes is modified somewhat from that recently advocated by Hubbs ('26). Some of the old technical names of genera and species are used, when their use appears still to be allowable, and where substitutions of new names would involve many changes in the body of the manuscript, which was largely completed at the time of the appearance of Hubbs' list. Furthermore, many of the quotations include the names used by Jordan and Evermann ('96, '98) and the extensive use of new terms might confuse a reader not familiar with the synonymy.

A key to all the species of fish which we know are found in Oneida Lake follows, but descriptions have been omitted since these can be found in Jordan and Evermann ('96 and '98) or in Bean ('03). Many of the names have been changed since the appearance of Bean's work, therefore a list of the species is here given, accompanied by the names used by Bean ('03).

LIST OF FISH KNOWN TO OCCUR IN ONEIDA LAKE

Scientific names used in this publication	Common name
(Names in brackets are those used by Bean, '03, in his Fishes of New York, or by Jordan and Evermann, '96, '98, '00).	
<i>Petromyzon marinus</i> Linnaeus	Lake Lamprey
[<i>Petromyzon marinus unicolor</i> (DeKay)]	
<i>Amia calva</i> Linnaeus	Bowfin
<i>Pomolobus pseudo-harengus</i> (Wilson)	Alewife
<i>Leucichthys artedi tullibee</i> (Richardson)	Tullibee
[<i>Argyrosomus tullibee</i> (Richardson)]	
<i>Salmo salar</i> Linnaeus	Atlantic Salmon
<i>Catostomus commersonii</i> (Lacépède)	Common Sucker
<i>Hypentelium nigricans</i> (LeSueur)	Hog Sucker
<i>Erimyzon sucetta oblongus</i> (Mitchill)	Chub Sucker
<i>Moxostoma aurcolum</i> (LeSueur)	Common Redhorse
<i>Moxostoma lesueurii</i> (Richardson)	Short-headed Redhorse
[<i>Moxostoma breviceps</i> (Cope)]	
<i>Cyprinus carpio</i> Linnaeus	Carp
<i>Rhinichthys atronasus</i> (Mitchill)	Black-nosed Dace

LIST OF FISH KNOWN TO OCCUR IN ONEIDA LAKE—Continued

Scientific names used in this publication	Common name
<i>Rhinichthys cataractae</i> (Cuvier and Valenciennes)	Long-nosed Dace
<i>Leucosomus corporal</i> Mitchill	Fallfish
[<i>Semotilus bullaris</i> (Rafinesque)]	
<i>Semotilus atromaculatus</i> (Mitchill)	Horned Dace
<i>Notropis deliciosus</i> (Girard)	Straw-colored Minnow
[<i>Notropis bleunius</i> (Girard)]	
<i>Notropis heterodon</i> (Cope)	Black-chinned Minnow
<i>Notropis bifrenatus</i> (Cope)	Bridled Minnow
<i>Notropis heterolepis</i> Eigenmann and Eigenmann	Cayuga Minnow
[<i>Notropis cayuga</i> Meek]	
<i>Notropis dorsalis</i> (Agassiz)	Gilbert's Minnow
[<i>Notropis gilberti</i> Jordan and Meek]	
<i>Notropis hudsonius</i> (Clinton)	Black Spot Minnow
<i>Notropis whipplii</i> (Girard)	Silverfin Minnow
<i>Notropis atherinoides</i> Rafinesque	Emerald Minnow
<i>Notropis rubrifrons</i> (Cope)	Rosy-faced Minnow
<i>Notropis cornutus</i> (Mitchill)	Common Shiner
<i>Exoglossum maxillingua</i> (LeSueur)	Cut-lips
<i>Notemigonus crysoleucas</i> (Mitchill)	Golden Shiner
<i>Hybognathus regius</i> Girard	Silvery Minnow
[<i>Hybognathus nuchalis</i> Agassiz]	
<i>Hyborhynchus notatus</i> (Rafinesque)	Blunt-nosed Minnow
[<i>Pimephales notatus</i> (Rafinesque)]	
<i>Ictalurus punctatus</i> (Rafinesque)	Spotted Catfish
<i>Ameiurus nebulosus</i> (LeSueur)	Common Bullhead
<i>Ameiurus natalis</i> (LeSueur)	Yellow Bullhead
<i>Schilbeodes gyrinus</i> (Mitchill)	Stonecat
<i>Schilbeodes miurus</i> (Jordan)	Variegated Stonecat
<i>Umbra limi</i> (Kirtland)	Mud Minnow
<i>Esox niger</i> LeSueur	Chain Pickerel
[<i>Lucius reticulatus</i> (LeSueur)]	
<i>Esox lucius</i> Linnaeus	Common Pike
<i>Anguilla rostrata</i> (LeSueur)	Eel
[<i>Anguilla chrysypa</i> Rafinesque]	
<i>Fundulus diaphanus menona</i> Jordan and Copeland	Barred Killifish
[<i>Fundulus diaphanus</i> (LeSueur)]	
<i>Percopsis omiscomaycus</i> (Walbaum)	Trout Perch
[<i>Percopsis guttatus</i> Agassiz]	
<i>Lepibema chrysops</i> (Rafinesque)	White Bass
[<i>Roccus chrysops</i> (Rafinesque)]	
<i>Perca flavescens</i> (Mitchill)	Yellow Perch
<i>Stizostedion vitreum</i> (Mitchill)	Pike Perch
<i>Hadropterus maculatus</i> (Girard)	Black-sided Darter
[<i>Hadropterus aspro</i> (Cope and Jordan)]	

LIST OF FISH KNOWN TO OCCUR IN ONEIDA LAKE—*Continued*

Scientific names used in this publication	Common name
<i>Percina caprodes zebra</i> (Agassiz)	Manitou Darter
<i>Boleosoma nigrum olmstedii</i> (Storer)	Tessellated Darter
<i>Poeciliichthys exilis</i> (Girard)	Iowa Darter
[<i>Etheostoma iowae</i> Jordan and Meek]	
<i>Catnotus flabellaris</i> (Rafinesque)	Fantail Darter
[<i>Etheostoma flabellare</i> (Rafinesque)]	
<i>Micropterus dolomieu</i> Lacépède	Small-mouth Black Bass
<i>Micropterus salmoides</i> (Lacépède)	Large-mouth Black Bass
<i>Lepomis megalotis</i> (Rafinesque)	Long-eared Sunfish
<i>Lepomis gibbosus</i> (Linnaeus)	Common Sunfish
<i>Ambloplites rupestris</i> (Rafinesque)	Rock Bass
<i>Pomoxis sparoides</i> (Lacépède)	Calico Bass
<i>Labidesthes sicculus</i> (Cope)	Brook Silversides
<i>Cottus bairdii</i> Girard	Sculpin
[<i>Cottus icthalops</i> (Rafinesque)]	
<i>Eucalia inconstans</i> (Kirtland)	Brook Stickleback
<i>Lota maculosa</i> (LeSueur)	Burbot

Our list of Oneida Lake fishes is not to be considered a complete one. We seined the shoals around the entire lake quite thoroughly, but we could not, of course, thoroughly fish the deep water, and we knew of no satisfactory way of securing complete collections from bordering marsh and swamp waters. Furthermore, the barge canal system, of which the lake is a part, has been considerably developed since the time when the bulk of our collections were made (in 1915 and 1916) and this has quite likely given access to species which we did not then find. Any one or all of the following listed species may be present in Oneida Lake, but no specimens were secured. The starred names represent species recorded in literature, but of which we have not actually seen specimens known to have been taken in Oneida Lake. This hypothetical list is as follows:

<i>Acipenser fulvescens</i> Rafinesque	Lake Sturgeon
* <i>Lepisosteus osseus</i> (Linnaeus)	Common Gar Pike
<i>Hiodon tergisus</i> LeSueur	Toothed Herring
* <i>Salmo fario</i> Linnaeus	Brown Trout
* <i>Salmo irideus</i> Gibbons	Rainbow Trout
* <i>Salvelinus fontinalis</i> Mitchell	Brook or Native Trout
<i>Moxostoma anisurum</i> Rafinesque	White-nosed Sucker
<i>Nocomis biguttatus</i> (Kirtland)	Lake Chub
<i>Couesius plumbeus</i> (Agassiz)	Plumbeus Minnow
<i>Margariscus margarita</i> (Cope)	Pearly Minnow
<i>Clinostomus clougatus</i> (Kirtland)	Red-sided Shiner
<i>Chrosomus erythrogaster</i> Rafinesque	Red-bellied Dace
<i>Villarius lacustris</i> (Walbaum)	Lake Catfish
<i>Ambloplites melas</i> (Rafinesque)	Black Bullhead
<i>Esox masquinougy</i> Mitchell	Muskallunge

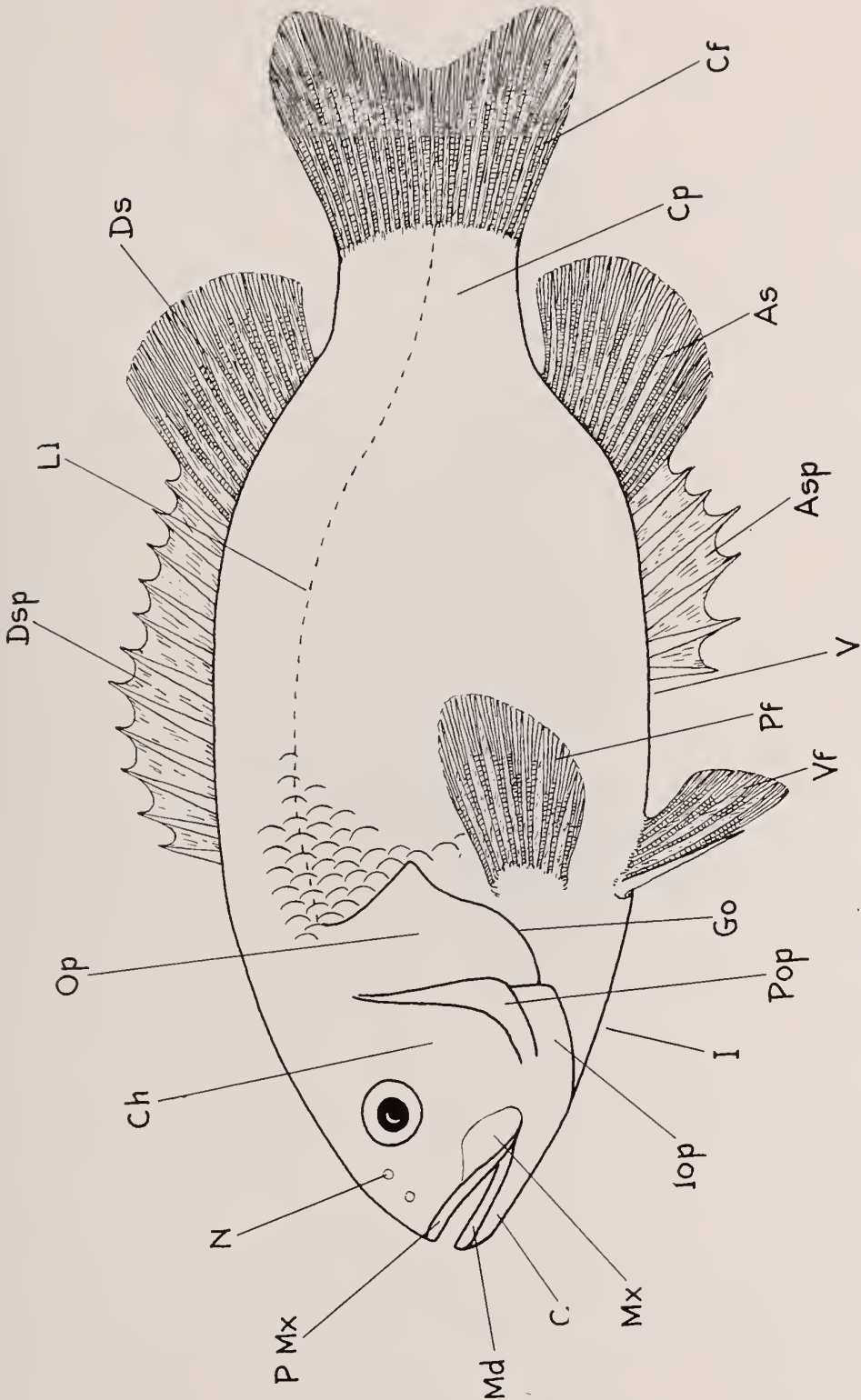


Fig. 179. Outline drawing of spiny-rayed fish (*Ambloplites rupestris*) to show external features.

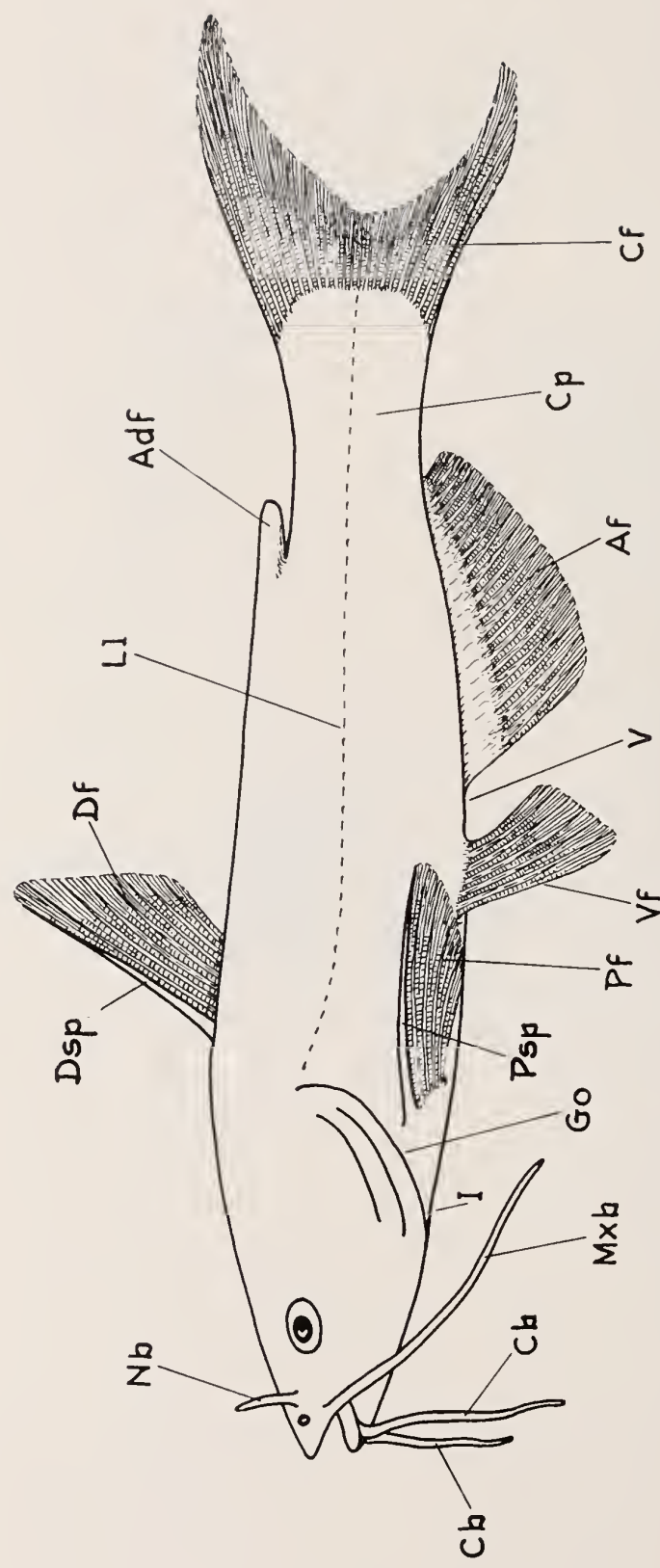


Fig. 180. Outline drawing of catfish (*Ictalurus punctatus*) to show external features.

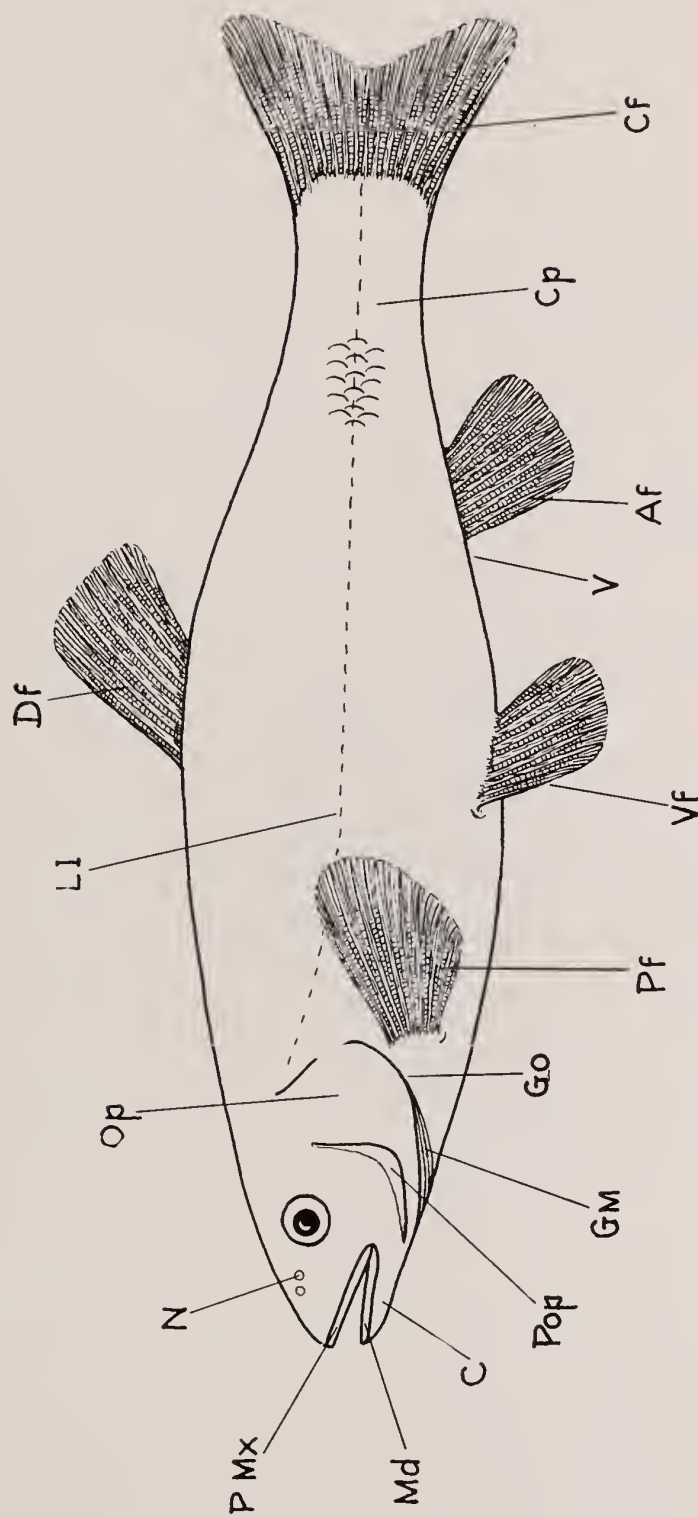


Fig. 181. Outline drawing of a minnow to show external features.

<i>Stizostedion canadense</i> (Smith)	Sauger
<i>Apomotis cyaneus</i> (Rafinesque)	Green Sunfish
<i>Aplodinotus grunniens</i> Rafinesque	Sheepshead
<i>Cottus cognatus</i> Richardson	Muddler

To be able to use the keys for identification and to comprehend descriptions of species fully, some attention should be given to fish structure, such as is shown by a large minnow like the Creek Chub, a sunfish—or better, a Rock Bass—and a catfish. The outline sketches of each of these three types (Figs. 179, 180 and 181) will be helpful in learning the external characters employed in identification. A glossary of technical terms follows the key, which may be used as a dictionary of terms used in it.

EXPLANATION OF ABBREVIATIONS FOR FIGURES 179, 180 AND 181.

Ad f.—Adipose Fin	Iop.—Interopercle
Af.—Anal Fin	ll.—Lateral Line
A sp.—Spinous portion of Anal Fin	Md.—Mandible
As.—Soft Anal Fin	Mx.—Maxilla
C.—Chin	Mxb.—Maxillary Barbel
Cb.—Chin Barbels	N.—Nostrils
Cf.—Caudal Fin	Op.—Opercle or Gill-cover
Ch.—Cheek	Pf.—Pectoral Fin
Cp.—Caudal Peduncle	P Mx.—Premaxilla
Df.—Dorsal Fin	Pop.—Pre-opercle
Ds.—Soft Dorsal Fin	Psp.—Pectoral Spine
D sp.—Spinous Dorsal Fin	V.—Vent or Anus
Go.—Gill Opening	Vf.—Ventral Fin
I.—Isthmus	

KEY TO THE SPECIES OF FISH KNOWN TO OCCUR IN ONEIDA LAKE, NEW YORK (Modified from Meek and Hildebrand, 1910.)

	PAGE
a. Gill openings 7 on each side; paired fins absent; mouth without jaws, but surrounded by a circular, concave buccal disk. Nostril single and median.	<i>Petr. omyzon marinus</i> 283
aa. Gill opening single on each side; paired fins present; jaws present; nostrils four.	
b. Ventral fins abdominal, when present.	
e. Tail heterocercal; a gular plate on lower jaw.	<i>Amia calva</i> 293
ce. Tail not heterocercal. No gular plate. Vertebral column ending near base of caudal fin.	
d. Pectoral fins each with a strong spine; head with long barbels; scales absent; dorsal fins two, the second adipose.	
e. Tail deeply forked; a bony ridge from skull to first dorsal fin, which can be felt under the skin. Black spots on the sides.	<i>Ictalurus punctatus</i> 369
ee. Tail not forked; bony ridge from skull to dorsal interrupted; color dark or variegated, not spotted.	
f. Adipose fin free from caudal fin behind.	
g. Anal fin long with about 24–27 rays; its ventral margin quite straight. Chin barbels light-colored. Pectoral spine with barbs.	<i>Ameiurus natalis</i> 382
gg. Anal fin short with fewer than about 24 rays; its ventral margin rounded. Chin barbels black or dusky.	<i>Ameiurus nebulosus</i> 372
ff. Adipose fin indistinct, connected with caudal fin behind.	
h. Pectoral spine nearly smooth; color dark, not variegated.	<i>Schilbeodes gyrinus</i> 384
hh. Pectoral spine distinctly serrated on its posterior margin. Color variegated	<i>Schilbeodes miurus</i> 385

- dd. Pectoral fins without strong spines; barbels minute or absent.
- i. Ventral fins without spines; second dorsal fin, if present, without rays, and small.
- j. Head without scales, or if present, very minute.
- k. Dorsal fin single.
- l. Ventral surface without long serrae.
- m. No teeth on jaws; anal fin short with less than 15 rays.
- n. Dorsal fin with more than 10 rays.
- o. Mouth with a long barbel at each corner. *Cyprinus carpio* 319
- oo. Barbels absent.
- p. Air bladder in two parts.
- q. Lateral line present.
- r. Scales about 60-70 in lateral series and reduced in size anteriorly.
 - Catostomus commersonii* 303
- rr. Scales fewer than about 60 in a lateral series; quite uniform in size.
 - Head very large and dorsally flattened. *Hypentelium nigricans* 312
- qq. Lateral line absent; body considerably compressed in the adult; young with a black lateral band; adults banded. *Erimyzon sucetta oblongus* 313
- pp. Air bladder in three parts.
- s. Head 4-4.5 in body; halves of lower jaw meeting in a distinct angle. Lips with coarse plicae; no papillae on lips. *Moxostoma aureolum* 316
- ss. Head 4.5-5.5 in body, conspicuously short and tapering. Lower lip truncate behind. *Moxostoma lesueurii* 318
- nn. Dorsal fin with fewer than 10 rays.
- t. Alimentary canal long with many coils. Peritoneum black. Teeth 4-4 with well developed grinding surface.
- u. Scales before dorsal fin fewer than 20, and about 40 in a lateral series.
 - Hybognathus regius* 365
- uu. Scales before dorsal more than 20 and conspicuously smaller here than on sides of body. *Hyborhynchus notatus* 366
- tt. Alimentary canal short with few coils. Peritoneum usually pale. Pharyngeal teeth, with narrow grinding surface, if present.
- v. Dentary bones parallel and united in the center of a three-lobed lower jaw.
 - Exoglossum maxillingua* 359
- vv. Dentary bones separate; lower jaw normal.
- w. Premaxillary protractile.
- x. Teeth 5-5; anal fin long with more than 12 rays; body deep and much compressed. Scales fine and uniform. *Notemigonus crysoleucas* 360
- xx. Teeth not 5-5; anal fin usually with fewer than 12 rays.
- y. Maxillary with a minute barbel near its tip. Body robust. Mouth large, extending beyond front margin of eye. Teeth 2, 4-5, 2.
- z. Scales large, rather uniform in size; about 45 in lateral series and 22 before dorsal fin. No black spot on dorsal fin. *Leucosomus corporalis* 337
- zz. Scales smaller on anterior than on posterior part of body; 65 or more in a lateral series and about 30 before the dorsal. A black spot at base of dorsal fin in front. *Semotilus atromaculatus* 340
- yy. Maxillary without barbel. Teeth in main row 4-4. Mouth not very large, not extending beyond front margin of eye.
- aa. Anal fin short with 7 or 8 rays. Dorsal fin about opposite ventral fins. Scales moderate; fewer than about 40 in the lateral series.
- ba. Scales on sides of body not notably deeper than long; those before the dorsal fin large, fewer than about 20.
- ca. Teeth in one row; 4-4.
- da. A conspicuous dark lateral band present.
- ea. Lower jaw bordered with black. *Notropis heterodon* 342
- eea. Lower jaw not bordered with black.
- fa. Lateral band very dark. Scales before dorsal fin very large, about 12 and regularly arranged. Snout blunt and shorter than the eye. Lateral band abruptly narrowed at tip of snout.
 - Notropis bifrenatus* 343
- ffa. Lateral band less deeply pigmented and composed of crescentic marks on lateral line scales. Snout about the length of the eye. Scales before the dorsal fin usually exceeding 12 and rather irregularly arranged. Lateral band encroaching broadly on snout. *Notropis heterolepis* 344
- dda. No conspicuous dark lateral band; colors pale. Lateral line distinctly decurved anteriorly. *Notropis deliciosus* 345
- cca. Teeth in two rows.
- ga. A conspicuous dark lateral band; lower jaw bordered with black.
 - Notropis heterodon* 342

	PAGE
gg ¹ . No lateral band.	
h ¹ . A prominent black caudal spot present. 18-20 scales before the dorsal fin.....	<i>Notropis hudsonius</i> 345
hh ¹ . No caudal spot. Mouth inferior; lips rather thick.	<i>Notropis dorsalis</i> 345
bb ¹ . Scales on sides of body closely imbricated, making the exposed portions notably deeper than long. 20 or more scales before dorsal fin.	
i ¹ . Body subelliptical and trim; head not large. Teeth 1, 4-4, 1. Adults usually with a black spot on the upper posterior part of the dorsal fin.....	<i>Notropis whipplii</i> 350
ii ¹ . Body compressed; anteriorly robust; mouth large. Teeth 2, 4-4, 2.	<i>Notropis cornutus</i> 355
aa ¹ . Anal fin long with more than 8 rays. Dorsal fin placed posterior to ventral fin.	
j ¹ . Snout short, about as long as the eye. Mouth noticeably oblique.	<i>Notropis atherinoides</i> 351
jj ¹ . Snout much longer than the eye; mouth less oblique.	<i>Notropis rubrifrons</i> 354
ww. Premaxillaries not protractile. Snout long; mouth subinferior. Maxillary with a minute barbel.	
k ¹ . Snout long, about twice length of the eye, and projecting decidedly beyond the mouth.....	<i>Rhinichthys cataractae</i> 335
kk ¹ . Snout shorter; less than twice width of eye; scarcely projecting beyond the mouth.....	<i>Rhinichthys atronasus</i> 333
mm. Jaws with teeth. Body long and slender. No ventral fins. Scales minute.	<i>Anguilla rostrata</i> 405
ll. Ventral line of belly with bony serrae.....	<i>Pomolobus pseudoharengus</i> 296
kk. Dorsal fin two, the posterior adipose.	
l ¹ . Scales cycloid. Sides silvery.....	<i>Leucichthys artedi tullibee</i> 297
ll ¹ . Scales etenoid; sides not silvery.....	<i>Percopsis omiscomaycus</i> 418
jj. Head with scales; these on cheeks or opercles.	
m ¹ . Jaws long and broad with some large canine teeth; lateral line present.	
n ¹ . Scales of operculum confined to its upper half.....	<i>Esox lucius</i> 396
nn ¹ . Scales on both upper and lower half of operculum.....	<i>Esox niger</i> 388
mm ¹ . Jaws short without large teeth. Lateral line wanting or but slightly developed.	
o ¹ . Premaxillaries non-protractile. Color dark brownish with indistinct markings.	<i>Umbra limi</i> 386
oo ¹ . Premaxillaries protractile. Color light with dark cross markings.	<i>Fundulus diaphanus menona</i> 415
ii. Ventral fins with spines.	
p ¹ . Body without scales. Dorsal fin with free spines.....	<i>Eucalia inconstans</i> 514
pp ¹ . Body with thin, cycloid scales. Dorsal fins two, both with rays.	<i>Labidesthes sicculus</i> 507
bb. Ventral fins thoracic; each with one spinous and 5 or fewer soft rays.	
q ¹ . Chin without a barbel.	
r ¹ . Body with true scales.	
s ¹ . Dorsal fin single, with 6-12 spines in anterior part of fin.	
t ¹ . Body deep and compressed; depth two-thirds or more of the length.	
u ¹ . Dorsal spines 5-7; dorsal fin similar to anal in size and shape. Body dark spotted.	<i>Pomoxis sparoides</i> 503
uu ¹ . Dorsal fin with 10 to 12 spines. Anal fin smaller than dorsal.	
v ¹ . Mouth large; maxillary extending to pupil. Anal spines 5-8. Tongue with teeth.	<i>Ambloplites rupestris</i> 498
vv ¹ . Mouth moderate; maxillary not extending beyond pupil. Anal spines 3. No teeth on tongue.	
w ¹ . Color pale, without red or brown markings. Adult with a black spot on the posterior dorsal rays.....	<i>Lepomis incisor</i> 486
ww ¹ . Color dark with red and blue markings.	
x ¹ . Opercular flap prolonged; black and without a distinct light border. Pharyngeal bones narrow, with many sharp teeth.....	<i>Lepomis megalotis</i> 490
xx ¹ . Opercular flap short, with a distinct red spot (yellowish in preserved specimens) on the posterior ventral portion. Pharyngeal bones broad with many blunt, paved teeth.....	<i>Eupomotis gibbosus</i> 492
tt ¹ . Body not decidedly deep; depth less than two-fifths the length. Mouth very large; maxillary extending to or beyond the eye.	
y ¹ . Scales on cheek in 10 rows. Young with a blackish lateral band. Maxillary extending beyond the eye in the adult.....	<i>Micropterus salmoides</i> 478
yy ¹ . Scales on the cheeks in about 17 rows. Young without lateral band but with a whitish caudal spot and sometimes with cross bars on sides. Maxillary not extending beyond the eye.....	<i>Micropterus dolomieu</i> 466

- ss¹. Dorsal fins two, distinct, or very slightly united.
 z¹. Anal fin with one or two spines.
 a¹¹. Pseudobranchiae well developed. Preopercle serrate. Mouth large.
 b¹¹. Mouth with many large canine teeth. A black spot at the base of the last dorsal spine. Size of fish large. *Stizostedion vitreum* 441
 bb¹¹. Canine teeth absent. Body yellowish, with broad, dusky transverse bars. *Perca flavescens* 424
 aa¹¹. Pseudobranchiae very small or absent.
 c¹¹. Premaxillaries protractile. Body with W-shaped markings on the sides. *Boleosoma nigrum olmstedii* 469
 cc¹¹. Premaxillaries not protractile.
 d¹¹. Cranium very broad between the eyes; snout conic and pig-like, projecting beyond the mouth. Sides with narrow, transverse bars or spots. Nape naked. *Percina caprodes zebra* 457
 dd¹¹. Cranium not broad between the eyes.
 e¹¹. Parietal region of skull depressed. Ventral line of belly with enlarged scales or with a naked strip left by their falling off. *Hadropterus maculatus* 456
 ce¹¹. Parietal region of skull not depressed, but strongly convex in cross section. No modified scales or naked strip on ventral line.
 f¹¹. Gill membrane scarcely connected. Dorsal fin VII to X — 10 to 11. *Pcecilichthys exilis* 463
 ff¹¹. Gill membranes broadly connected. Soft dorsal with 12–14 rays. *Catnotus flabellaris* 465
 zz¹. Anal fin with three spines. Body deep and compressed. Sides silvery, with several narrow, dark, longitudinal lines along the sides. *Lepisma chrysops* 422
 rr¹. Body without true scales and more or less armed with prickles or with a few scale-like plates. Cheeks with a bony stay below eye, ending in a spine on the opercle. *Cottus bairdii bairdii* 512
 qq¹. Chin with a barbel; dorsal with more than 40 rays. *Lota maculosa* 517

EXPLANATION OF TERMS USED IN THE KEY.

- Abdominal ventral fins.* Ventral fins considerably behind pectoral fins, and the pelvic girdle to which they are attached free from the pectoral girdle. Figs. 180 and 181.
- Adipose fin.* A rayless, commonly fleshy fin-like structure on the back, behind the dorsal fin. Fig. 180.
- Air bladder.* A membranous sac filled with gas, and located dorsally in the body cavity.
- Anal fin.* The unpaired fin on the ventral side of the fish.
- Barbel.* An elongated, more or less thread-like appendage of the head.
- Body.* The body is the region from the gill openings to the anus, but the term is used in comparative measurements to include the entire fish exclusive of the caudal fin.
- Bony stay.* A bony ridge extending from the eye region backward across the cheek and ending in a spine on the opercle. Present in sculpins.
- Branchiostegal membrane.* The lower or ventral part of the opercular fold, supported by bony rays, the branchiostegals.
- Branchiostegals.* Bony rays supporting the branchiostegal membranes. Fig. 181.
- Buccal disk.* A circular funnel-like structure around the mouth in lampreys.
- Canine teeth.* Elongated, conical teeth on the jaws, much longer than the other teeth.
- Caudal fin.* The unpaired fin at the posterior end of the body; the tail fin.
- Caudal peduncle.* The narrow, posterior part of the body which supports the caudal fin.
- Caudal spot.* A pigment spot near the middle of the base of the caudal fin.

Cheek. The fleshy area behind and below the eye and anterior to the opercle.
Fig. 179.

Chin. Region between the limbs of the lower jaw. Fig. 179.

Compressed. Flattened from side to side, as in the case of the sunfish.

Cranium. The part of the skull enclosing the brain.

Ctenoid scales. Scales with minute spines on their distal exposed portions. The spines can be felt by gently rubbing the fish with the finger, or they can be seen with a lens.

Cycloid scales. Scales without spines, but with concentric lines called circuli and annuli. Scales are smooth to the touch.

Dentary bones. The principal or anterior bones of the mandibles. They usually bear teeth. Fig. 179.

Depth of fish. The greatest vertical diameter; usually taken just in front of the dorsal fin.

Depressed. Flattened in the up and down direction, with body low and broad.

Disk teeth. Tooth-like tubercles on the oral disk of lampreys, surrounding the mouth.

Dorsal fins. Unpaired fins of the back. Fig. 179.

Emarginate fin. Fin with the margin containing a shallow notch as in the caudal fin of the Rock Bass. See Fig. 179.

Fin formula. A formula showing the number and kinds of rays in a fin, e.g., D.X., 12. The capital letter represents the name of the fin (dorsal); the Roman numeral, the number of spines; and the Arabic numeral the number of soft rays. When there are two dorsals present this fact is indicated by means of a dash; D. XII -II, 12.

Forked tail. Tail fin conspicuously notched or divided into two similar lobes, each with an acute tip. Fig. 180.

Fusiform. Spindle-shaped. Applied to the body when it tapers at each end and is but slightly compressed.

Ganoid Scales. Rhomboid scales or plates covered with an enamel-like substance, or ganoin.

Gills. Breathing organs of fish; typically composed of a bony supporting arch, with two rows of gill filaments on its posterior side and a row of gill rakers on its anterior side.

Gill clefts or slits. Spaces between the gills, connecting the pharyngeal cavity with the gill chamber.

Gill cover. The flap-like covers of the gills and gill chambers: the opercles.
Fig. 7.

Gill openings. As here used, meaning the external openings of the gill chambers. A single pair is present in all true fishes found in fresh water. Fig. 179.

Gill rakers. Fine rods or tubercles on the anterior face of a gill arch.

Grinding surface. A flattened contact area of a tooth.

Gular plate. The flat, oblong plate on the chin of the Bowfin.

Head. Region of the fish anterior to the gill openings, measured from the tip of the snout to the posterior edge of the opercle.

Head in length. The distance from the snout along the cheeks to the extremity of the opercles as contained in the distance from the snout to the base of the caudal fin.

Height. As applied to a fin, it is usually the length of its longest ray.

Heterocercal tail. Tail with the backbone prolonged dorsally into the upper lobe of the caudal fin. This lobe of the fin is usually more highly developed than the lower, but in *Amia* the difference is not marked.

Hyoid bones. Bones in the floor of the mouth, supporting the tongue.

Inferior mouth. Mouth decidedly on the under side of the head, opening downward.

Interspinal. Bones to which the rays of the fins are attached.

Isthmus. The narrow bar in the floor of the pharynx, separating the gill chambers.

Fig. 179.

Lateral band. A horizontal pigmented band along the sides of a fish.

Lateral line. A line of sensory organs along each side of the body. Fig. 179.

Length. The length of a fish is considered to be from the tip of the snout to the posterior end of the vertebral column. The total length, however, is from the end of the snout to the tip of the caudal fin. The length of a fin is taken along its base.

Mandible. Lower jaw.

Maxillary bones. Bones attached to the premaxillaries laterally; sometimes lying alongside the premaxillaries as in the Rock Bass (Fig. 179), or continuous with them as in the catfish (Fig. 180).

Naked. Applied to the body when scales or other dermal modifications are absent.

Nape. Region just behind the occiput.

Nostrils. Openings of the nasal chambers. Fig. 179.

Nuptial tubercles. Outgrowths on head or body in the form of granules or denticles that appear in breeding male fish. Called also pearl organs.

Occiput. Posterior dorsal part of the head or skull. Fig. 179.

Opercles. The same as the gill covers. Fig. 179.

Opercular bone. The flat, more or less triangular bone supporting the gill cover or opercle.

Operculum. The same as the gill cover or opercle.

Opercular flap. A posterior prolongation of the opercle, usually colored differently from the rest. Found in sunfishes. Fig. 179.

Oral valves. Thin, membranous flaps used in breathing; just inside the mouth opening on both upper and lower jaws.

Orbit. Cavity of the skull containing the eye.

Palatines. Bones just back of the vomer in the roof of the mouth, one on each side.

Papillae. Small roundish, fleshy projections, as on the lips of some suckers.

Papillose. Covered with papillae.

Parietals. Bones of the sides of the skull, above and just back of the eyes.

Pearl organs. Hard tubercles or granules developing on breeding male suckers and minnows. Called also nuptial tubercles.

Pectoral arch. A bony framework usually connected with the skull and supporting the pectoral fins.

Pectoral fins. The anterior paired fins, attached to the pectoral arch. Fig. 179.

Pelvic arch. The bony structure supporting the ventral or pelvic fins.

Pelvic fins. The same as the ventral fins.

Peritoncum. The lining membrane of the body cavity.

Pharyngeal bones. Bones behind the gill arches, near the entrance of the œso-phagus. As a rule they bear teeth.

Pharyngeal teeth. Teeth on the pharyngeal bones. In minnows they may be removed with needles or fine cutting instruments. The pharyngeal bones can be seen, covered with thin mucosa, in the back part of the gill-chamber. The teeth are in one or two rows on each bone, and the tooth formula is written as follows: 1, 4-4, 2. This means that there are four large teeth in the outer row, on each bone, while the inner row of one bone bears one tooth, that of the other side, two. The teeth on the lesser row, therefore, are represented by the outer numbers and those of the larger row by the middle numbers on each side of the dash. Sometimes the lesser row is wanting. If the greater row should have four teeth on each bone, the formula would be 4-4.

Pigment. Coloring matter.

Plicae. Flat, parallel folds or wrinkles, as on the lips of some suckers.

Plicate. Possessing plicae.

Postorbitals. Bones of the orbital series, situated just behind the eyes.

Premaxillaries. Anterior pair of bones of the upper jaw, meeting in front and usually bearing teeth. Fig. 179.

Pseudobranchiae. Small gills on the upper, inner side of the opercle. Called also opercular gills.

Pterygoids. Bones in the posterior part of the roof of the mouth just back of the palatines.

Pyloric caeca. Tubular projections from the prehepatic or duodenal part of the intestine.

Preopercle. The bone in front of the opercle and more or less parallel with it. Fig. 179.

Protractile. Applied to the premaxillaries when these are capable of being extended forward. When premaxillaries are retracted, they are bordered behind by a groove. Fig. 179.

Radii of scale. Lines on proximal part of a scale, radiating from near center to base.

Ray. A supporting rod for a fin. There are two kinds: hard (spines) and soft rays.

Scale formula. This has three numbers separated by dashes, e.g., 6-56-12. The first number represents the number of the scales between the lateral line and a point on the middle of the back about halfway between the dorsal fin and the head. The middle number represents the number of scales crossed by the lateral line—or the number in the transverse series if the lateral line is incomplete or absent—beginning near the dorsal edge of the gill opening and extending to the last vertebra. The last number represents the number of scales between the lateral line and the front edge of the anal fin or, in some cases, the base of a ventral fin.

Serrae. Structures resembling saw teeth.

Serrate. Possessing serrae.

Snout. Anterior portion of the head. Measured from the tip of the snout to the front margin of the eye.

Soft fins. Fins with soft rays only, designated as soft dorsal, etc.

Soft rays. Rays that are soft, finely segmented and commonly branched at their tips. Fig. 179.

Spines. Unsegmented rays, commonly hard and pointed. Fig. 179.

Spiracle. An opening in the head of some fishes, above and anterior to the gill opening.

Sub. In word composition means below, somewhat, not quite, etc.

Superior. As applied to the mouth, means that it opens in a more dorsal or upward as opposed to anteriorly facing or ventral direction.

Supplemental maxillary bone. A small bone along the upper edge of the maxillary bone, closely united with it.

Tail. The part of the fish posterior to the anal fin, composed of the caudal peduncle and the caudal fin.

Tercete. When applied to the body, means cylindrical or tapering.

Terminal mouth. The mouth is so designated when situated in the horizontal axis of the head with neither chin nor snout projecting.

Thoracic. Applied to the ventral fins when they are far forward, close to the pectoral fins, and the pelvic arch is attached to the pectoral arch. Fig. 179.

Truncate. Applied to the caudal fin, when its posterior margin is nearly straight, as if cut off.

Vent. Posterior opening of the alimentary canal; the anus.

Ventral fins. Posterior paired fins, attached to the pelvic girdle; called also pelvic fins. Fig. 179. The ventral fins are considered abdominal in position when they are nearer to the anus than to the pectoral fins.

Ventral line. An imaginary median line on the ventral surface of a fish.

Vertebral column. The series of vertebrae forming the backbone or spinal column.

Villiform teeth. Minute teeth crowded in velvety bands.

Vomer. Bone of the anterior part of the roof of the mouth; commonly triangular and often with teeth.

ANNOTATED LIST OF ONEIDA LAKE FISH

By CHARLES C. ADAMS and T. L. HANKINSON

***Petromyzon marinus* Linnaeus.** LAKE LAMPREY, LAMPER, LAMPER EEL, LAMPREY. The Lake Lamprey is a very abundant and harmful species which attaches itself, by means of its oral disc, to the bodies of fishes and sucks their blood. Frequently it attaches itself also to the bottoms of moving launches and row-boats. This is a land-locked form considered to be the same species as the Great Sea Lamprey. It is probably safe to state that in the course of the year tons of fish are killed by lampreys in Oneida Lake, yet no systematic effort has been made to control this pest.

Breeding Habits and Life History. Our knowledge of its breeding habits and life history is due mainly to the studies by Gage ('92) and Surface ('98, '99) of lampreys of the Cayuga Lake basin. Lampreys do not breed in lakes but upon

the shoals of their tributary streams. They begin migrating about the last of April, according to Surface ('99, p. 240), when the temperature of the water reaches about 45° F (l.c., p. 223). It is probable that there is a response not only to the current but also to *warming water*, according to one of Gurley's laws (Gurley, '02, p. 409). In general, the males tend to precede the females and select the sites for their nests just above shoals or riffles on sand (Surface, '99, p. 216). Migration takes place during the night, and they rest during the day, attached to stones (l.c., p. 214). A male, or a pair, makes a nest by moving the stones to the margin of an area about two feet in diameter (l.c., p. 214). Deposition of the eggs is described by Surface as follows (l.c., pp. 220-221): "Many stones are left at the sides and especially at the upper margin of the nest, and to these both lampreys often cling for a few minutes as though to rest. While the female is thus quiet, the male seizes her with his mouth at the back of her head, clinging as to a fish [host]. He presses his body as tightly as possible against her side, and loops his tail over her near the vent and down against the opposite side of her body so tightly that the sand, accidentally coming between them, often wears the skin entirely off of either or both at the place of closest contact. During the time of actual pairing, which lasts but a few seconds, both members of the pair exhibit tremendous excitement, shaking their bodies in rapid vibration, and stirring up such a cloud of sand with their tails that their eggs are at once concealed and covered. As the eggs are adhesive and non-buoyant, the sand that is stirred up adheres to them immediately, and covers most of them before the school of minnows in waiting just below the nest can dart through the water and regale themselves upon the eggs." As soon as the eggs are shaken together the lampreys begin to move stones from one part of the nest to another, and to bring more loose sand down over their eggs. They work at this from one to five minutes, then mate again; thus making the intervals between mating from one to five minutes. The number of eggs in the average female is about 65,000 (Gage, '93, p. 460), or from 25,000 to 35,000 according to Surface ('99, p. 200). From 20-40 are deposited at a time, and the whole period lasts from 2-4 days. (p. 222). The duration of the spawning season, according to Reed and Wright ('09, p. 391), extends over a period of about three weeks, from May 25 to June 15. Surface ('99, p. 223) gives the period from 4-6 weeks. The eggs hatch in from one to three weeks (l.c., p. 200). Gage ('93, p. 448) thought the larvae remained in the nest about a month, until about half an inch long (12-15 mm). The young undergo a complete metamorphosis. The larvae look much like worms and live in burrows in the sandy, quiet margins of the streams. When they reach a length of about five inches (120-160 mm) they transform (Gage, '93, p. 452). The transformation from a burrow-living, blind, sedentary, worm-like animal to the active, eyed, predatory kind requires probably a month or two (p. 454). These transformations begin late in August and extend to the middle of October (p. 455).

Coventry ('22, p. 131) records observations made on Lake Lampreys near Toronto, Canada, in a portion of the Humber River where it was about a hundred feet wide and two feet deep, except occasional holes six feet deep, with the river bed composed of clean gravel or shingle and slabs of solid rock. There were frequent rapids. Nests of the lampreys were found in the more rapid waters of



Fig. 182. Cleveland Bay, north shore of Oneida Lake. June 28, 1916.



Fig. 183. Godfrey Point, showing prevalent conditions along northeast shore of Oneida Lake. July 14, 1916.



Fig. 184. Mathews Point and rocky, sedge covered shore on north side of Oneida Lake. June 23, 1916.



Fig. 185. Broad rocky beach of West Potter Bay. June 26, 1916.

this part of the river and in shallow water not over two feet deep. The nests were shallow depressions from about 12 to 30 inches in diameter. The following account of the nests and the spawning is given: "The actual process of laying was watched a number of times. The two animals concerned cease carrying stones and take up a position with their heads at the upper edge of the nest; this is achieved in one of two ways; either both attach themselves to the large stone already mentioned, or the female alone takes this position, the male clinging to the top of her head; at once after this the posterior halves of their bodies twist together for about a complete turn and simultaneously make very rapid flapping movements, so fast, indeed, as to be almost vibrations. During this process, which lasts only a few seconds, eggs may be seen pouring from the female as a number of small white specks, which become mixed with the very small stones and sand stirred up by the agitation of the parents' bodies. As soon as this movement ceases eggs and sand together settle down at the bottom of the nest. The male and the female then separate and resume their stone-hauling, often moving stones from points a foot outside the nests and placing them on the parapet, but after a few minutes the laying process is repeated; how often this interruption and resumption of laying may occur was not determined, but certainly as many as four times.

"In the large nest already mentioned as being the work of four animals one and the same male was seen to pair with each of two females, eggs from different mothers being mixed in the nest.

"The eggs when they are first laid stick so firmly to stones that any attempt to detach them usually destroys them; after about fifteen minutes, however, they do not adhere at all so closely and may be washed off with a gentle stream of water from a pipette; in the course of a day or two they lie loose among the pebbles.

"During the period over which nesting was watched the temperature of the water varied from 18° C. on June 4th, to 23° C. on June 21st and 27th, the temperature being taken between 8 and 9 o'clock A. M., standard time.

"The nesting season lasted approximately a month."

At Constantia, Mr. Dan Miller, Foreman of the Oneida State Hatchery, presented us on September 9, 1915, with five specimens (Collection No. 140) of larval lampreys which he had gathered for bait from the stripping pond east of the stripping house on Frederick Creek. They swam about in the thin mud with great speed, and the larger ones looked like large earthworms or "night crawlers." Whether these larvae are Brook Lampreys (*Entosphenus appendix*) or Lake Lampreys is not known, as the larval forms are indistinguishable (Gage, '93, p. 429). Our largest specimen is about 4 inches (105 mm) long, with eyes beginning to develop, and hence it must have been nearly ready to transform. The smallest specimen was 1 7/8 inches long.

Foreman Scriba found large numbers of lamprey larvae in the muddy bottom of the same pond from which our specimens came. Scriba's statement (Bean, '09, p. 186) is as follows: "The lamprey eels come up the streams here in June to spawn, and we caught and destroyed over 300 in Frederick Creek between the stripping-house and the hatchery; a little later we drew the water out of the stripping-house pond and the mud on the bottom of the pond was a living mass of

small lamprey eels from 1-6 inches in length. We disposed of as many of them as possible. Several game protectors were here at the time, and every one said he never saw such a sight." Bean ('12, p. 189) reports that the "lampreys spawn in creeks near Oneida Lake in May or June. . . . In 1911, the Lake Lamprey was spawning in Frederick Creek at Constantia, about May 25th, continuing for one week. It usually spawns in June."

Gage ('93, p. 445) was not able to determine satisfactorily the fate of Lake Lampreys after spawning. Some have been of the opinion that like salmon and eels they die; or that they may return again to the lake, although, as Gage suggested, the atrophied condition of the digestive system makes this improbable. Surface ('99, p. 224) records finding large numbers of dead lampreys in the pools of the streams.

Habitat. The habitat of the lamprey varies with its development. After hatching, probably a month is spent in the nest, then it changes its habitat from the shoal to the quiet sandy margins of the stream. Surface ('99, p. 202) describes the larval habitat as follows: "These larvae (the indistinguishable Brook and Lake Lampreys) can be found in almost any sand-bank or drift of dirt and *débris* from near the source of the stream (the highest spawning beds) to its very mouth, having been carried far below the lowest spawning beds by the high water. Their food is most abundant in the concave side of a turn in the stream where the current causes a whirlpool and quiet water, and where there is a consequent deposit of sediment and fine organic material. They appear to greatly prefer such a place to a bare sand-bank, doubtless because their food is more abundant, where the finely comminuted organic material is also deposited with the mud and sand." The conditions on the muddy bottom of the stripping pond at Constantia should also be recalled. Here they live in their burrows. After functional transformation is complete they migrate down stream to the lake and assume the predacious life, feeding upon the larger fishes until sexual maturity, when they again return to the streams to spawn. The spawning stream used by these lampreys is Frederick Creek, tributary of Scriba Creek at Constantia. Others we did not locate.

Food. The food of the larvae, according to Gage ('93, p. 457), "consists of microscopic organisms separated in some way from the constant stream of water drawn into the combined pharyngeal and branchial chamber." It is thus probably a plankton-feeder. Surface ('99, p. 192) speaks of it as "feeding in the larval state upon minute organisms (especially diatoms) which live in the organic sediment beneath the water." He does not, however, give the detailed evidence for this opinion. Whether or not food is taken during the period of transformation is not known. Gage ('93, p. 438) has shown that the digestive system previous to the breeding season atrophies within two weeks, and no food is taken during the breeding season. The food of the adult, outside of the breeding season, was solely blood, according to his observations. Dawson ('05, p. 96), however, found in the stomach of a December specimen bits of striated muscle about 12 mm long, a gill and a rib of a small teleost fish. The gill was 1 cm long and bore filaments 5 mm in length; the rib was 2 cm long. It is impossible to tell whether the lamprey came by this small fish directly or from the intestine of a larger fish which served as its prey. In any case, it appears that the attached *P. marinus unicolor* may feed not only on blood but on more solid tissue.

The damage done to the large fishes in Oneida Lake is very extensive and attracts much attention on account of the large number of dead fish seen floating upon the surface and washed upon the shores during the summer. The following is a list of the species which have been found, during our investigation, dead or dying and bearing lamprey scars:

Bowfin	Collection No. 100
Tullibee	Nos. 535, 560, 2412
Eel	Seen
Carp	No. 104
Common Sucker	Nos. 75, 92, 93, 518, 614
Common Bullhead	Nos. 89, 92, 122, 327, 409
Chain Pickerel	Nos. 152, 352
Large-mouthed Black Bass.....	No. 98
Pike Perch	No. 560
Perch	No. 560
Burbot	Seen

On July 14, 1916, in the vicinity of the deep water a mile or two off Cleveland, probably 50 injured and dead Tullibees were observed floating upon the surface. Most of them had only recently died and were in fresh condition; two dying specimens were picked up. The lake surface was calm and the chances are that these fish had been killed in the immediate vicinity and had not drifted far. Many had been killed also in deep water. With a motor boat we scouted a large area and examined all fresh-looking floating fish found; almost all of them were Tullibees. This observation is confirmed by Mr. George H. Travis, of Cleveland, N. Y., who informed us that he also had found that the lampreys are extremely destructive to the Tullibees of Oneida Lake. Several specimens of the Common Sucker, many Perch, and a large catfish were also seen but not examined for lamprey scars. The weather for several preceding days had been very warm and had warmed the water of the lake considerably. It is not unlikely that the warmth drove the Tullibees into the deeper and cooler water and made them, through the concentration of their numbers, easy prey to the Lamprey. We preserved 16 specimens (No. 560) all of which were scarred close to a pectoral fin, except two, which were scarred on the belly near the anal fin. Two specimens have additional marks on the sides of the body. The wounds are deep, penetrating into the tissues below the skin.

In the case of two specimens of the Common Bullhead (Nos. 92, 327) which had been attacked the intestine projected through the ventral body wall; and the same was true in the case of a large specimen of Large-mouthed Black Bass (No. 98). The only specimen of the Bowfin (No. 100) that we secured from the lake was one found dead and bearing a lamprey scar.

During February and March, according to Surface ('99, p. 211), lampreys feed voraciously, probably preparing themselves for the fasting period of the breeding season. This early spring destruction does not, however, agree with our observations on Oneida Lake. The greatest damage is observed there after the breeding season is past, during July and August. Bean ('12, p. 189)

states that active destruction begins in June or July. During the season of 1909 (Bean, '10, p. 255), Foreman Scriba of Constantia reported that, "The lamprey eel is becoming a very serious thing in Oneida Lake. During the months of July and August last the surface of the lake was literally covered with dead fish, most of them cisco and pike perch, about all with lamprey eel marks on them."

Bean ('09, pp. 192-193) reported great damage done by lampreys in July and August, 1908, when great quantities of dead fish were washed ashore on Sylvan Beach; but Mr. Egbert Bagg, who reported this to him, found only about 25% with lamprey scars. Later Bean reports ('10, p. 276) for 1909 that in July there were a great many dead fish in Oneida Lake. These were "chiefly ciscoes but some whitefish, and almost all the fish had been killed by lampreys." In August they were not so abundant as in July. For 1912 he ('13, p. 274) says: "The lamprey, usually in July and August, attacks whitefish, lake herring, bullheads, pike perch, suckers and other fish for the purpose of sucking out their blood." In his reports for 1914, Bean says ('15, pp. 352-353), "The annual destruction of Tullibee by Lampreys in Oneida Lake had begun late in June, 1914. On the 28th I saw about twenty of the dead Tullibee floating at the surface in various parts of the lake. The Tullibee seemed to be attacked in the deepest water."

Distribution Records. Our lamprey collection included the following numbers: Nos. 140, Sept. 9, 1915, larvae from the stripping-pond at Constantia; No. 96, Sept. 3, 1915; No. 105, Sept. 3, 1915, and No. 154, Sept. 10, 1915, from the bottom of our boats. Twenty-eight other specimens (Nos. 80, 108, 335, and 342) were secured for us by fishermen.

Enemies. Little definite information was secured on the harmful agencies affecting lampreys. Surface ('99, p. 205) states that a Brook Lamprey was found in the stomach of a Green Heron, *Butorides virescens virescens*. This suggests that some of the previous water-birds may also eat Lake Lampreys. He also reports (p. 206) instances of these lampreys being eaten by the common water-snake (*Natrix sipedon*). Minnows of the genera *Notropis* and *Rhinichthys*, he reports (p. 206), feed upon Lamprey eggs in the nests. On dissection the eggs were found in the stomachs of the minnows.

At the close of the breeding season, spent individuals are frequently found infested with water mould *Saprolegnia*, according to Gage ('93, p. 446) and Surface ('99, p. 207).

Economic Relations and Control. The main economic importance of the lamprey is due to its destructiveness to food-fish. The character and extent of the injury has been discussed under the subject of the food of the lamprey (p. 289). The injury it does to mature fish is so conspicuous that the lamprey is commonly recognized as the greatest enemy of fish in the lake; yet an equal or even greater destruction of young fish may occur without being readily noticed.

The larval lampreys are excellent bait, as Gage ('93, p. 457) has pointed out. He states regarding the larval marine lampreys, that "at Owego, on the Susquehanna River, however, quite a business is carried on in supplying larval lampreys to fishermen of all kinds, and many are shipped to distant points." And Bean ('13, p. 274) states: "The larvae furnish excellent bait for the larger game fish, and many thousands of them are so employed."



Fig. 186. Bowfin (*Amia calva*).



Fig. 187. Common shiner (*Notropis cornutus*).

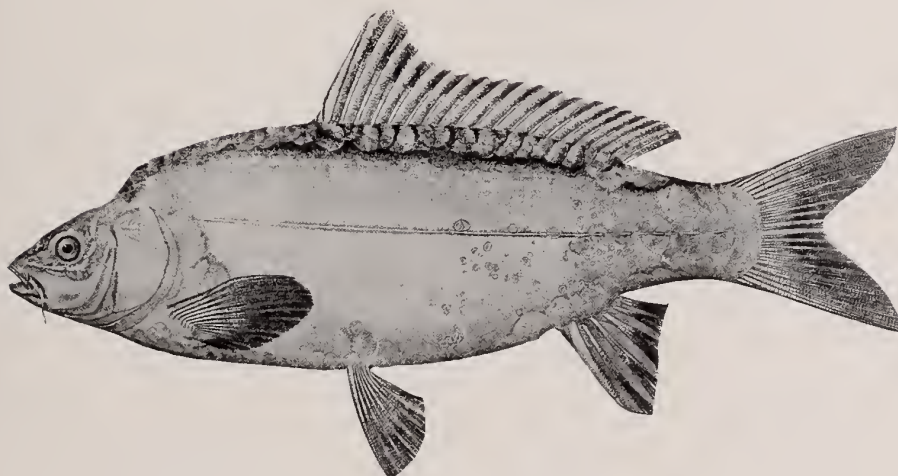


Fig. 188. Carp (*Cyprinus carpio*). The form with few scales.



Fig. 189. East Potter Bay and wooded shore. July 27, 1916.



Fig. 190. East Potter Bay. Dip-net erected at nesting site of Common Sunfish. June 28, 1916.

Gage ('93, p. 461) early recognized that the most important period for combatting lampreys was during their life in the streams. He urges destruction before spawning, and suggests a "dam with a fish-way, the fish-way leading into an isolated enclosure where the lampreys could be easily removed and disposed of, or a weir of some kind could be constructed at slight expense." Building upon this suggestion, Surface ('99, p. 227) constructed a weir in the inlet of Cayuga Lake and caught over 1600 specimens (l.c., p. 239); but with hand-nets he had even greater success, as by that means more than 1800 were killed (l.c., p. 243).

Bean ('13, p. 274) suggests: "The only means available for the prevention of this loss is the capture of the lamprey in weirs and other fishing apparatus during its ascent of stream in which it spawns, and the destruction of the larval lampreys in the mud and sand shoals near the mouths and along the banks of creeks tributary to the lake."

The thriving condition of the larval lampreys in the stripping pond at Constantia has suggested a new method of lamprey control which may supplement the methods previously suggested. This consists in building ponds with muddy bottoms, tributary to streams, or in damming streams, and allowing the larval lampreys to accumulate as they do in the bottom of the stripping pond at Constantia—"a living mass of small lamprey eels." After the lampreys have accumulated here these ponds should be drained, through a fine screen if necessary, to allow the mud to dry out thoroughly. Harrowing the bottom would expose the young lampreys and kill them by drying. Under some circumstances it might be possible to kill the larvae by means of copper sulphate, to obviate draining, or in basins where complete drainage is not possible.

Another partial remedy would be a campaign of education that would interest anglers and fishermen in the great value of the larvae as bait. Surface ('99, p. 193) remarks: "The advantage of larval lampreys for bait is that they are lively, moving all the time and attracting the attention of such fishes as are hunting for moving and living material upon which to feed, and they are very tough. One young lamprey will often endure long enough to catch two or three or even more voracious fishes." The reaction to moving objects to which they attach themselves is so powerful that this form of behavior might be used to advantage for their destruction. During the day we frequently took from the bottom of our boats a few specimens of lampreys. During the breeding season, on or near the breeding grounds a moving raft might be devised to which they would attach themselves and be trapped.

Clearly there is urgent need of further study of these animals, with particular attention to the influence of dessication and copper sulphate on the larvae and on the attacking reaction of the adults.

References. Bean, '03, '09, '10, '12, '13, '15, '16; Coventry, '22; Dawson, '05; Gage, '93; Gurley, '02; Jordan, '18; Meek, '89; Reed and Wright, '09; Surface, '98, '99. (See Gage, 1928, Suppl. 17th. Ann. Rep., N. Y. Cons. Dept., pp. 158-191.)

Amia calva Linnaeus. BOWFIN, DOGFISH, GRINDLE, MUDFISH, LAWYER. (See Fig. 186.) One dead Bowfin found by us in Oneida Lake, and the testimony of anglers, point to its presence in small numbers there. In bodies of water

where it is common, it is frequently taken by hook, often to the chagrin of the fisherman who expected a bass or a pickerel, but its gameness enables it to furnish as much sport as any other fish of its size. For this reason and from the probability that prejudice against it as a source of food will be overcome, and from its zoological interest on account of its being a primitive form and a survivor of a type relatively abundant in geological times, it may yet become more generally considered a desirable inhabitant of our waters.

Breeding Habits and Life History. Situations suitable for the breeding of Bowfins in Oneida Lake are abundant. These are shallows among thick vegetation at the lake margins, stream mouths, in bays and similar places. These fish make nests, which are more or less circular areas from which plants have been cleared and the soil removed so as to form depressions and expose roots or other objects to which the eggs may be attached. The male fish guards the eggs and later accompanies the schools of young until, according to Forbes and Richardson ('09, p. 40), they are about four inches long. Reighard ('03, p. 66) found the breeding season near Ann Arbor, Michigan, to be from about the middle of April to the middle of June. Dean ('99, p. 250) states that in Wisconsin, April 1 to early June is usually the maximum period of spawning. Details concerning the life history are given by Reighard ('03), Dean ('99), and Gill ('07, p. 431).

Evermann and Clark ('20, p. 318) found Dogfish spawning toward the end of April in the Lake Maxinkuckee region. Nests were made by hollowing out places in muck, eighteen to thirty inches in diameter. A male was usually found by each nest guarding the eggs.

Richardson ('13, p. 407) near Havana, Illinois, in April found nests in water two and a half to three feet deep, choked with vegetation. The nests were about two and a half feet in diameter, four inches deep and nearly circular. In the bottom were grass roots to which many of the eggs adhered. There were from two thousand to five thousand eggs in each. The male fishes, about twenty inches long, hovered over the nests and were very bold. Kelly ('24, p. 73) notes a male Bowfin guarding its young and being very aggressive. It would bite the end of a pole held before it.

Habitat. The relatively few Bowfins in Oneida Lake probably live in the deep water usually, but come to shallow water at night and during the breeding season. This appears to be their usual habit, according to Reighard ('03, p. 65) and Hankinson's observations in other lakes, chiefly in Michigan.

The fact that no Bowfins were taken in the many collections we made in shallow water, between the middle of June and the middle of September is significant. Had the fish been breeding during this time, the trammel-net placed about plant-covered shoals would undoubtedly have obtained a few, yet their habit of hiding in the bottom material (l.c.) may have prevented their being caught. Some of the young should have been among the thousands of other small fishes we took from shallow water, if they had been there in any numbers, since the young appear to be taken in a seine with little difficulty (Dean, '99, p. 254).

Coker ('17, p. 2) calls it a "lover of sluggish waters," and "It seems to like the weedy waters, frequenting the shallows at night and returning to the deeper places by day." He mentions Bowfins being found during the winter so closely

huddled in gravelly pockets among water weeds that two at a time were often impaled on a spear.

Food. Forbes ('88, p. 463) studied the food of twenty-one specimens from Illinois and found it to be wholly animal in nature, about 33 per cent consisting of fish, 5 per cent of mollusks, 40 per cent of crustaceans, and 2 per cent chiefly of insects. Reighard ('03, p. 65) describes the Bowfin as a "powerful and voracious fish feeding chiefly on crayfish and small fishes." He also (l.c., p. 64) notes a case of their eating meat-scrap and raw potato. Hankinson has caught them, in Michigan and Illinois, with hooks baited with minnows, earthworms, and once with boiled ham. Reed and Wright ('09, p. 393) report the Bowfin swallowing young marsh-birds. Marshall and Gilbert ('05) found crawfish and minnows in the stomach of seven examples. Hankinson ('06, p. 176) found a Blunt-nosed Minnow and a Large-mouth Black Bass in the alimentary canal of a Bowfin. Evermann and Clark ('20, pp. 293, 317) found chiefly crawfish and minnows, with the remains of other small fishes, mollusks, and algae, in Bowfins from Lake Maxinkuckee. Coker ('17, p. 3) notes that with its strong sharp teeth it has been known to bite a two pound fish in two at a single snap, and says that its food is principally fish, crawfish and mollusks.

Distribution Records. Only one Bowfin (No. 100) was taken by us in Oneida Lake. It was about $17\frac{1}{8}$ inches (435 mm) in length. A specimen (No. 397) from Cross Lake taken by C. W. Van Horn, September 11, 1916, is $18\frac{3}{4}$ inches (476 mm) long. This was taken with a snell-hook and a dead minnow, in a rapid current. Another specimen (No. 1513) was taken at Mud Lock, Long Branch, Onondaga Lake, April 6, 1917, by Frank Seeley, and is $18\frac{5}{8}$ inches (474 mm) long. Mr. J. D. Black, of Constantia, reports them once taken in Three Mile Bay.

Enemies and Disease. The Bowfin we found in Oneida Lake had a lamprey scar near one pectoral fin. The young when unaccompanied by the male (Reighard, '03, p. 60) are attacked by predacious fish and undoubtedly other enemies. Stiles and Hassall ('12, p. 355) record *Taenia filicollis* Rudolph from this species; Leidy ('04, p. 188) records *Taenia filicollis* Leidy from *Amiatus*. LaRue ('26, p. 285) found larval trematodes in the eyes of *Amia* from Douglas Lake, Michigan.

Six fishes examined by Evermann and Clark ('20, Vol. 1, pp. 293-319) contained internal parasitic trematodes in the mouth and the throat, and cestodes and acanthocephalans in stomach and intestine. A trematode, *Azygia tereticolle* (Rudolph) was in the gills of four of the specimens. One fish had an *Argulus americanus* Wilson on the outside of its body. Two different species of leeches were on three specimens of Bowfin. The authors mention the prevalence of tape-worms in this fish taken elsewhere than in Lake Maxinkuckee.

Marshall and Gilbert ('05, p. 516) found parasitic worms in each of the thirteen fishes they examined. These were trematodes, *Azygia tereticolle* Stafford, from mouth and stomach, cestodes from stomach and intestines, and a leech in the mouth. Ward ('12, p. 226) shows that 27 out of 32 Bowfins examined were parasitized with trematodes, cestodes, nematodes and acanthocephalans, averaging 157 worms to a fish. Ward ('94a) describes a trematode, *Distoma opacum* Ward, parasitic on the Dogfish.

LaRue ('14, p. 144) records *Proteocephalus ambloplitis* Leidy, a cestode, from this species taken in Lake Erie and Lake St. Clair, Michigan, and *Proteocephalus perplexus* LaRue from specimens taken in the Illinois River by H. B. Ward and in North Carolina by Joseph Leidy. Wilson ('19, p. 230) found *Argulus americanus* Wilson on the outer surface of the Bowfin. This parasite was also found in Lake Maxinkuckee (Evermann and Clark, '20, Vol. 2, p. 79).

Ward and Whipple ('18) note two nematode parasites from *Amia*, which are *Haplounema immutatum* Ward and Magath, and *Echinorhynchus thecatus* Linton. Two other trematodes parasitic in *Amia* are *Leucercuthrus micropteri* Marshall and Gilbert, and *Microphallus opacus* (Ward).

Economics. Since the food of the Bowfin is similar to that of Black Bass and Pike Perch in Oneida Lake, it would compete with them for food in an important way if it became abundant. Its increase in Oneida Lake does not appear desirable, with so many other better fishes there, some of which it might replace. It is used in the South as food and there is a good market for Bowfins in New York City, to which large shipments have been made from the Illinois River (Forbes and Richardson, '09, p. 40). Miles ('13) describes a method of preparing it which makes it very palatable. It is skinned from the tail toward the head, cleaned, the backbone removed, and then divided into halves that are cut into pieces and fried like doughnuts. When smoked, too, the fish becomes quite palatable, and there are still other ways of preparing it. Hankinson has found the preparation of this fish for the table attended with too much difficulty on account of its tough skin and heavy scales. The Bureau of Fisheries (Coker, '17) has advocated its more general use as food and recommends a regular fishery for Bowfins, which "will tend to restore and to maintain a proper balance between this and other species that dwelt together and in competition before man began to disturb natural conditions." Garman ('91, p. 147) tells of young a few inches long being caught by the hundreds for trot line bait; for this they are very desirable on account of their hardness.

Angling. Almost any bait will attract Bowfins. Those caught are frequently large and powerful and furnish considerable sport with the tackle. Frequently they break hooks and cut lines with their sharp teeth, and when abundant they may be a nuisance for this reason. Young Bowfins make good bait for pickerel and pike (Goode, '84, p. 659).

References. Baker, '16; Bean, '03; Coker, '17; Dean, '98, '99; Evermann and Clark, '20; Forbes, '88; Forbes and Richardson, '09; Gill, '07; Gilbert, '05; Goode, '84; Kelly, '24; LaRue, '26; Leidy, '04; Marshall and Gilbert, '05; Miles, '13; Reed and Wright, '09; Reighard, '03; Richardson, '13; Stiles and Hassall, '12.

Pomolobus pseudoharengus (Wilson). ALEWIFE, SAWBELLY, BRANCH HERRING, SKIP JACK, GOLDEN SHAD. We have obtained only a single specimen (No. 9) from Oneida Lake. This was taken December 9, 1914, from South Bay, by I. A. and A. W. Thierre. It is also the only one they had taken from the lake.

The specimen was probably only a straggler from Lake Ontario, coming up the Oswego and Oneida Rivers. This species normally lives in salt water but ascends streams to spawn as does its relative the Common Shad. Evermann ('01, p. 343) gives a good brief account of it as follows: "In Cayuga Lake, Lake-

Ontario, and other small lakes in New York tributary to the St. Lawrence, it is found in considerable numbers and appears to be landlocked. In Lake Ontario it is excessively abundant, great multitudes sometimes dying in early summer.

"Just how it got into these lakes has never been satisfactorily determined. It is claimed by many that they were introduced into Lake Ontario under the impression that they were young Shad. However that may be, it hardly accounts for their presence in the small interior lakes of New York.

"The species is known to be common in the Gulf of St. Lawrence and it is not at all unlikely that many find their way every spring up the St. Lawrence to Lake Ontario, though this is by no means certain. It may be that they are actually landlocked in these various lakes, that they breed there and are able to maintain themselves notwithstanding the dying of many every year.

"There is no doubt that those found in these lakes are very much smaller than those found along the coast, which indicates that they are a dwarfed form, the small size being the result of a restricted environment and an insufficient food supply. . . .

"In Lake Ontario it rarely exceeds 5 or 6 inches in length, the majority seen probably not exceeding 3 or 4 inches. Those of 2 to 4 inches in length are often used as bait. Their bright silvery color makes them very attractive to game fishes, but they are quite delicate and will not stand much punishment."

Bean gives the following additional information ('02, pp. 303-304): "In the rivers the alewives appear to eat nothing, but they can be captured with small artificial flies of various colors. Their eggs are somewhat adhesive and number from 60,000 to 100,000 to the individual. They are deposited in shoal water; spawning begins when the river is at 55° to 60° F. The period of hatching is not definitely known, but is believed to exceed four days.

"During the spring and summer the young grow to the length of 2 or 3 inches; after their departure from the streams nothing is known of their progress, but it is believed that they reach maturity in four years. . . .

"The Branch Alewife, though full of small bones, is a very valuable food fish and is consumed in the fresh condition as well as dry salted, pickled and smoked. The fry can be reared in ponds by placing adults in the waters to be stocked a little before their spawning season; and they furnish excellent food for bass, rockfish, trout, salmon and other choice fishes. The proper utilization of the immense oversupply of these fish in Lake Ontario has become a serious economic problem.

"Alewives are caught in seines, gill nets, traps and pounds, and they are often taken by anglers with artificial flies." Greeley ('27, p. 61) notes their use for bait in Lake Ontario.

References. Bean, '02, '03; Evermann, '01; Greeley, '27; Smith, '92; Wright and Allen, '13.

Leucichthys artedi tullibee (Richardson). TULLIBEE, MONGREL WHITEFISH, ONEIDA LAKE WHITEFISH. The Tullibee is known locally as the "Oneida Lake Whitefish," and so far as can be learned, Oneida is the only one of New York lakes in which it is now common; formerly it was abundant in Onondaga Lake. It is the only member of the *Salmonidae* common in Oneida

Lake at present, and it is the only one we found there. Dr. Tarleton Bean gives evidence of the occurrence of Whitefish (*Coregonus* sp.), and Herring (*Leucichthys* sp.) other than Tullibees. He states (Bean, '10, p. 276) that on July 19, 1909, there were a great many dead fish in Oneida Lake, chiefly ciscoes, but also some Whitefish; and in 1914 (Bean, '15, p. 348), both Tullibee and Whitefish eggs were planted in Oneida Lake. The Tullibee is probably the "cisco" referred to here, but elsewhere he apparently distinguished two kinds of ciscoes in Oneida Lake ('10, p. 289). Mr. J. D. Black, Protector at Oneida Lake, did not know of any true Whitefish having been taken from the lake.

Tullibees of the lake have great potential food value, but are available at present chiefly by illegal method of capture. Since they are very rarely caught by hook, the only direct evidence that most anglers and other visitors get of their occurrence in the lake is from the many floating dead individuals seen in summer.

Breeding Habits and Life History. James Annin, Jr., noted their spawning in Onondaga Lake (Bean, '03, p. 240). He says: "They generally commence running up onto the shoals about November 15, and the season extends into December. They come up to the banks or gravelly shoals and spawn in from 3 to 6 and 7 feet of water." F. C. Gilchrist (Forest and Stream, April 7, '92, quoted by Bean, '03, p. 239), states that they spawn from about the 25th of October to November 10, and that they prefer shallow water close to shore, with clean sand bottom; that: "during the day, they may be seen in pairs and small schools, poking along the shores, but at night they come in thousands and keep up a constant loud splashing and fluttering." Before spawning, according to Gilchrist (l.c., p. 240), they take little if any food, and afterwards are very thin, lank, and dull in color. A specimen taken in the fall contained many large ova (No. 327). Bean ('13, p. 262) states that the greatest difficulty experienced in collecting Tullibee eggs for cultural purposes arises from the scarcity of males and the small amount of milt they furnish; but Mr. J. D. Black found the males very abundant at spawning time, probably ten times as numerous as the females, and he easily distinguished them from the females by their smaller size, more trim appearance and undistended abdomens. Mr. Black, who while working at the Constantia Hatchery has had experience with this species, told us that Tullibees come to the shoals in early November. If the weather is fair they remain to spawn, but if the water is rough they go to deep water to spawn instead of into the shallows. He says that spawning is especially active during the first snow-storm, and accompanying the breeding activity is the moving of thousands of Tullibees near the surface, which they agitate in such a way that it becomes foamy, and on quiet nights can be seen over extensive areas of the lake. The hatchery nets that are set on the bottom, on the spawning beds, in water from 5-16 feet deep, do not contain Tullibees at such times, making it appear that the fish are then generally at the surface.

Mr. Black says the fish spawns in water less than sixteen feet in depth, on rocky shoals. Favorite places are on Shackleton Shoals, about Leete Island, Dutchman's Island, and on the shoals off Constantia, but the fish probably spawn wherever bottom conditions and depth are right.

Habitat. Tullibees live in the deep waters of Oneida Lake, and, according to fishermen, they are largely confined in summer to the deepest waters, which are off Cleveland. Our finding many dead ones there in fresh condition, as well as two dying specimens, during a calm spell on July 14, 1916, gave some evidence of their being especially numerous in this locality at the time. Bean ('13, p. 262) says that in summer the best fishing places are in the deepest water of the lake. They come to shallow water in the spawning season, and to some extent at other times. Bean (l.c.) records one seven inches long taken in a net on the west side of Scriba Creek at Constantia. In all of our collections in shallow water of Oneida Lake made during three years, no Tullibees were taken, making it very probable that the young do not visit shoals, at least in summer and in the daytime. Night observations on fishes of shallows were not made by us. Wagner ('08a, p. 123) reports catching Tullibees in Wisconsin Lakes at a depth of eighty-five or more feet, where there was little oxygen (about 1% of the amount at the surface), and as they were abundant under such conditions he considers the species one that lives well in large shallow lakes, apparently of the type of Oneida Lake.

Food. Five specimens were opened by F. C. Baker ('16, p. 161), and only one contained food, which was almost entirely cladocerans (*Leptodora hyalina*). This specimen, which was nearly a foot (29 cm) long, was purchased at a Syracuse market, in November, and was said to have come from Oneida Lake.

Distribution Records. Forty-six specimens of Tullibees were added to our collection (Nos. 327, 486, 534, 559, 560 and 2412). They measured from 11-15 inches in total length, but most of them were near the larger dimension. Thirty-seven of the fish were found dead, during July, 1916. Seven were obtained from markets in Brewerton and in Syracuse (Nos. 327, 486), with assurances that they came from Oneida Lake. Two were living (No. 560) but they were weak and probably dying; they were found near the deepest part of the lake, a mile or two off Cleveland, on July 14, 1916. The occurrence of Tullibees in Oneida Lake is frequently referred to by Bean ('09, p. 200; '10, p. 289; '13, p. 262; '15, p. 348; and p. 351). Scriba ('11, p. 160) and Jordan and Evermann ('11, p. 33) also record it from Oneida Lake.

Enemies. Tullibees are attacked by the Lake Lamprey in Oneida Lake and undoubtedly many are destroyed by it, as shown in our account of the Lake Lamprey. Bean ('02, p. 314) states that young Whitefish (*Coregonus clupeiformis*) are eaten extensively by Pike Perch, Black Bass, Pike, Pickerel, and Fresh-water Ling, all of which are common in Oneida Lake and probably destroy young Tullibees also. It is probable also that many parasites of other herring (*Leucichthys* and of Whitefish (*Coregonus*) attack Tullibees.

Economics. Tullibees have been caught in large numbers in Oneida Lake, for the markets, and sold fresh or salted, but now their capture is practically prohibited by law, since the use of nets suitable for taking them is not permitted. It is regrettable that some means of properly using this apparently large supply of good human food can not be found, especially since Tullibees have been reared at the Hatchery at Constantia and planted in the Lake in large numbers, and at considerable expense. This has been discontinued in recent years, however. The

eggs were obtained from fish caught in the Lake. Wagner ('08a, p. 124) considers it a very promising fish for introduction into certain large shallow lakes.

Angling. The reason that Tullibees are seldom caught by hook appears to be that proper methods of angling for them are not employed. Bean ('13, p. 62) describes a way of catching them as follows:

"The rig used for this kind of fishing includes a flexible wire attached to a line and to a sinker which holds the wire near the bottom. This wire is bent at the free ends at a small angle and each end supports a No. 16 Sproat Hook. The eye of the hook is attached to the end of the wire and the leaders are twisted either with a very small minnow or a small piece of some silvery fish. The locality must be baited for some time until the fish become accustomed to feeding at the spot." He further states that a landing net must be used and that the fisherman should move or jiggle the line almost constantly. Bean ('14, p. 348) quotes Dan E. Miller, Foreman of the Constantia Hatchery, who describes the catching of seven Tullibees from 6-9 inches long in Oneida Lake. A small trout hook was used, baited with worms. The difficulty of capturing Tullibees with hook and line and of legalizing netting them has led to the abandonment of their culture in Oneida Lake. (Pratt, '19, p. 92.)

References. Baker, '16; Bean, '92, '97, '02, '03, '09, '10, '11, '13, '14, '15; Cobb, '04; Goode, '03; Jordan and Evermann, '02, '11; Pratt, G. D., '19; Scriba, '11; Wagner, '04, '08a.

Salmo salar Linnaeus. ATLANTIC SALMON. The Atlantic Salmon is an important food and game fish in rivers tributary to the North Atlantic and in lakes connected with them. It occurs also to some extent in the Great Lakes and other bodies of water, where it has been introduced, and once it was found in Oneida Lake but there is no evidence of its presence there now.

Breeding Habits and Life History. Salmon run up streams from the North Atlantic in the fall, from October to December, and their eggs are laid in depressions which they make with their noses and tails (Bean, '02, p. 325) on sandy or gravelly stream bottoms.

Nichols and Heilner ('20) record 41½ pounds as the weight of the largest example of this species taken by rod and reel. Smith ('92, p. 196) notes one taken weighing 42 pounds.

Habitat. Little appears to be known of the conditions under which Atlantic Salmon thrive best in the sea. They visit streams in the spring, apparently for feeding (Jordan and Evermann, '03, p. 166), and then again in the fall for breeding. They may become abundant in lakes connected with these streams.

Two subspecies, the Land-locked Salmon (*Salmo salar sebago*) and the ouananiche (*Salmo salar ouananiche*) live permanently in fresh water (Jordan and Evermann, '96, p. 487; Bean, '92 and '02; Ward, '01).

Food. Bean ('01, p. 324) says that the Atlantic Salmon feeds on herring, capelin and crustaceans in the sea, but takes no food in fresh water. This however, is doubted by Jordan and Evermann ('03, p. 166). Goode ('03, pp. 445-446) says: "The Salmon while it remains in the sea or in the brackish estuaries takes particular delight in feeding on crustaceans and their eggs, small shrimps, and young crabs. When in the rivers they eat but little, though they are at



Fig. 191. Scene near mouth of Potter Bay Creek. June 27, 1916.



Fig. 192. Open meadow shore of Billington Bay. June 20, 1916.



Fig. 193. Marsh adjoining lake at Billington Bay. June 21, 1916.



Fig. 194. Thicket type of shore. East Shaw's Bay. July 26, 1916.

times eager enough for food, as is shown by their eager rushes at the angler's fly-hook." Clinton (1815, p. 499) says that it eats nothing during its residence in Oneida Lake. Professor Baird stated that in the North Atlantic they feed on *Mysis* (Smith, '92, p. 190).

Distribution Records. DeKay ('42, p. 242) says: "They were formerly very abundant in the lakes in the interior of the State, which communicated with Lake Ontario. . . . I have seen some from Oneida Lake weighing ten and fifteen pounds." Smith ('92, p. 195) notes a former abundance in Lake Ontario and tributaries.

Clinton (1815, p. 499) says: "Abounds in Fish Creek, which discharges itself into Wood Creek, about a mile from Oneida Lake. Vast numbers are taken in that lake." Clinton is in error as to the relation of these streams, for Wood Creek is a tributary of Fish Creek, one of the inlets at the east end of Oneida Lake. He further states that it makes its appearance in May and remains until winter. DeKay ('42, p. 242) says he has seen sea Salmon from Oneida Lake weighing ten and fifteen pounds.

Enemies and Disease. Bean ('02, p. 326) states that among the worst enemies of the Atlantic Salmon are trout, eels, suckers and frogs, and that sheldrakes, kingfishers, gulls and bitterns destroy the fry. Ward ('10, p. 1168) gives a list of parasites reported from *Salmo salar*. In this there are 28 cestodes, 19 trematodes, 14 nematodes and 14 acanthocephalans as internal parasites. Leidy ('04, p. 186) notes a *Dibothrium* from *Salmo salar*. Three ectoparasites are given, namely, two leeches and one copepod.

Economics. The Atlantic Salmon furnishes an example of the disappearance of a large and excellent food-fish from Oneida Lake that was once common there. DeKay ('42, p. 242) blames "artificial impediments" for the decrease of its numbers. Fishing was undoubtedly responsible to some degree. Mitchell (1815, p. 500) tells of Indians spearing the fish at night in Oneida Lake. Of the natural enemies mentioned above by Bean ('02, p. 326), Eels and suckers are abundant in the lake. Very likely the barge canal, the Caughdenoy dam and other artificial features have ended favorable conditions for the Atlantic salmon, but what these conditions are and how they might be reestablished is an important subject for future study.

References. Bean, '92, '02, '12; Clinton, 1815; DeKay, '42; Goode, '03; Jordan and Evermann, '96 and '03; Mitchell, 1815; Smith, '92; Ward, '01, '10.

Castostomus commersonii (Lacépède). COMMON SUCKER, WHITE SUCKER. This Sucker is abundant in Oneida Lake, where the large ones live in the deeper waters and the small ones school in the marginal shallows and stream mouths. They are easily distinguished from the many minnows found there, by the inferior mouth with papillose lips, the long dorsal fin with more than ten rays, as in all suckers, and the series of three or more rather distinct dark blotches on the sides of the body. These markings are absent in large examples of the species. The little fish tend to school by themselves when many are present in shallow water, and are not often caught in large numbers with other fish. The Common Sucker is the only species of sucker at all numerous in the lake, and differs from the rarer Red-horse, Hog Sucker and Chub Sucker most promi-

nently in the unevenness in size of its scales, which are largest near the tail and become noticeably smaller forward. Common Suckers are food-fish of considerable value on account of their abundance, general distribution, large size and the readiness with which they are captured; but their numerous bones, an unpleasant flavor said to be present in individuals from shallow, warm waters, and probably an impression that they are often filthy in food habits forbid their being well liked. This sucker is seldom, if ever, caught by hook in Oneida Lake and is of little interest to anglers.

Breeding Habits and Life History. Early in the spring, soon after the ice has gone out of lakes and streams and the water begins to grow warm, these suckers "run", which means that they ascend streams to spawn. They move at night to riffles or swiftly flowing water and prefer such places to quiet pools (Forbes and Richardson, '09, p. 86). Reighard ('15, p. 225; '20, p. 4) finds that they breed in streams where the water is swift and the bottom of gravel, but he considers it possible that the essential requirements for breeding are suitable bottom and running water, that they may breed in the lake, and that the young suckers occurring in the shallow water there are still on their breeding grounds (l.c., p. 225). After spawning, Common Suckers return to the lakes (Bean, '03, p. 102). Breeding fish are commonly large, weighing two or three pounds, but Fowler ('12, p. 474) found individuals 3 inches long with well developed milt and roe, like those nearly two feet in length, and males four inches long with tubercles on the caudal and anal fins. He says: "I have every reason to believe these small fish were also spawning with the large ones, as I captured specimens of similar disparity in size in the same waters in the spawning season." Breeding males have tubercles or pearl organs commonly on the anal and on the lower half of the caudal fins, and sometimes on the other fins and on the upper half of the body. Fowler (l.c.) discovered this last condition in fish about a foot in length. One of our large Oneida Lake specimens (No. 351), about sixteen inches long, has tubercles on all of the fins and on the upper part of the body. Males possibly spawn without these organs (l.c., p. 475). Fowler found no tuberculate females in the species.

In spawning, two of usually many males present on the spawning bed crowd alongside a female (Culbertson, '04, p. 65; Reighard, '20, p. 10; Hankinson, '19, p. 136). The breeding fish are very shy at such times (Reighard, '20, p. 5), and their markings are peculiar (l.c., p. 6; and Hankinson, '19, p. 135), with a prominent light stripe above a dark one on each side of the body. The sexual difference as to color is slight. The male has pearl organs, which very rarely occur in the female (l.c., p. 136). The pearl organs enable males to keep their positions with reference to the female in spawning (Reighard, '20, p. 12).

On April 8, 1921, Hankinson watched suckers spawning in Chittenango Creek, from the bridge at Bridgeport (Fig. 223). All of the fish were of the same size, about 17 inches long (No. 4206), and in the water the markings appeared similar to those noted by Reighard. A light stripe bordered a distinct dark one along each side of the body. Two fish were often seen pressing on each side of a third one, and sometimes even more would crowd into this group. The spawning act was like that described by Reighard ('20, p. 13). No distinction of sex could be noted.

Stewart ('26, p. 149) found Common Suckers spawning in Beebee Lake, at Ithaca, N. Y., in April and in May. He has studied the development from the egg up to about two inches in length and has given figures of the different stages. Embury ('15, p. 227) notes the growth of young Common Suckers as follows: Five months, 2 inches long; one year, 3 to 4 inches long; two years, 6 to 7 inches long. Hubbs and Creaser ('24) have studied the growth of young Common Suckers from Douglas Lake, Michigan, taken from June 5 to August 16, 1921. In these 72 days, the fish grew from about 15 mm to 50 mm.

Oneida Lake fish studies were not carried on by us at the time suckers spawn, but several streams enter the lake, and these undoubtedly furnish them spawning-grounds; and possibly they spawn to some extent in marshes, as they do about Cayuga Lake (Allen, '14, p. 56). Mr. J. D. Black tells us that they spawn in Black Creek at Cleveland. Some appear to spawn late, for specimens from the Brewerton market in May contained a large number of nearly ripe eggs.

Our many collections of young from the lake showed a season's growth. Those taken in June, 1916, were an inch or a little less in length. Ten collections made at this time contained about 250 fish. (See numbers in first group under Oneida Records below.) In early July many little suckers were taken in shallow lake-water, in nine collections; they ranged in size from 1 to 1½ inches, while in late July all found were about 1½ inches long, and none as small as an inch. In September, 1915, young suckers appeared uncommon on the lake shoals. About thirty fish were taken and they were mostly from two to three inches in length. Our three fall collections contained many specimens between three and four inches long, the usual dimensions attained by suckers in Oneida Lake during their first season. The suckers taken or seen by us from the deep water of Oneida Lake measured from about eight (No. 360) to seventeen and a half inches (No. 351). A market collection (No. 627) contained young averaging about eight inches long.

Habitat. Common Suckers thrive under a variety of conditions. Forbes ('86, p. 10) finds that they inhabit nearly all lakes and streams in regions where they abound. In small streams they dwell in the deepest parts. Fowler ('06, p. 157) describes their habit of bunching in deep pools of streams, when they are easily disturbed by a sudden movement on the bank, or by a shadow, which will cause them suddenly to seek shelter near bank or rocks. Hubbs and Creaser ('24, p. 372) describe the movements of young Common Suckers, stating that on reaching a length of about 30 mm, they move into areas of rather dense but shallow vegetation.

In lakes, the largest Suckers live in deep water while the small ones frequent the marginal shallows and tributary streams, often in large schools. Hankinson ('08, p. 207) found large ones in water as deep as 80 feet, in Walnut Lake, but they appeared most abundant in water from 15 to 40 feet deep; the maximum depth of the lake was a trifle over 100 feet. Reighard ('15, p. 223) found Common Suckers in all habitats in Douglas Lake. In September one was caught in 72 feet of water, but in July and August none was taken below 43 feet, which is the depth of the thermocline, below which they do not appear to live in summer. Hankinson ('16, p. 144) found Common Suckers about a foot and a half long common in water as shallow as 8 feet, in Lake Superior. Leathers ('11, p. 246)

noted them from the deep water of Saginaw Bay. Greeley ('27, p. 57) found Common Suckers abundant in the Genesee System of New York State, in both warm and cold waters, and found it to be the only sucker common in trout streams. In Oneida Lake large suckers are evidently abundant in the deep water since none was seen or caught in shallow water, though many large ones were found dead. Their abundance in deep water was further attested by the statements of lake fishermen. We obtained one specimen (No. 519) of this species, about 10 inches long, in a gill-net set at a depth of 12 feet.

Food. Baker ('16, p. 164) examined the stomachs of three adult specimens from Oneida Lake and found mud, plant remains, mollusks and insects in them. Hankinson ('08, p. 207) took large suckers in Walnut Lake, which had eaten a variety of food: caddis-worms with their cases, midge larvae and other insects, small bivalve mollusks, amphipods, and Entomostraca. Young suckers in Oneida Lake appear to feed largely on Entomostraca. Baker ('16, p. 166) and Forbes ('80, p. 73) got similar results from two small ones examined. Reighard ('15, p. 224) examined a young sucker 2 inches long from Douglas Lake, that had been feeding on the sandshoals, September 1, 1911. Shells of a species of Cladocera filled its alimentary canal; but only 2 or 3 copepods were present. There was no sand, so he concludes that the young suckers were feeding not upon bottom food but wholly upon plankton. Hankinson ('16, p. 145) found the principal food of eight little Common Suckers, about 2.5 inches long, from a shoal in Lake Superior, to be chironomid larvae. Entomostraca, winged insects, and algae had also been taken. Three larger suckers, 7 to 8 inches long, taken in some shallow ponds near Lake Superior, had eaten chiefly chironomid larvae and algae. According to Kendall and Goldsborough ('08, p. 24), young fish between one and two inches long were found feeding upon diatoms, desmids, and blackfly larvae.

Clemens ('23, p. 176; '24, p. 107, with Dymond, Bigelow, Adamstone, and Harkness) made detailed studies of 184 Common Suckers from Lake Nipigon, Ontario. By tabulated data it is shown that the species partakes abundantly of invertebrate life and algae, including diatoms. Numerous species of water insects, with crustaceans, mollusks, rotifers, and protozoans are eaten. It is concluded by these investigators ('24, p. 154) that as the suckers grow they add more and more of the larger bottom organisms to their diet. Chironomid larvae form a considerable proportion of the food of specimens between 2 and 8 inches in length. Later considerable amounts of ephemerid nymphs, caddis-worms, mollusks, and other large forms are taken. Algae, especially diatoms, and bottom plankton continue to form considerable portions of their diet throughout life. Bigelow ('24, p. 83), as results of his special studies of the food of this species, concludes that the Common Sucker is largely a carnivorous fish in Lake Nipigon and that although a considerable amount of ooze and diatoms was found to have been taken, the bulk of the food proved to be animal matter. He has divided the early life of the fish into three periods according to the nature of the food: (1) rotifer-eating stage, length 1.9 cm; (2) Cladocera-eating stage, length 2.3-5 cm; (3) insectivorous stage, over 5 cm in length. Adamstone ('24, p. 78) reports on an examination of 39 Common Suckers. Amphipods, with chironomids and filamentous algae formed a large part of the food. Dymond ('26, p. 39) states that the Com-

mon Sucker in Lake Nipigon feeds on mollusks, Mayfly nymphs, chironomid larvae, caddis larvae, amphipods (*Pontoporeia hoyi*), diatoms, and a considerable variety of minute bottom-living organisms. Stewart ('26, p. 181) gives results of food studies of 162 of these suckers, both young and adult. Chironomids formed about $\frac{1}{3}$ of the food of the adult and $\frac{2}{3}$ of the food of the very young (12-16 mm long); the rest of the food was composed of a large variety of insects and other invertebrates. Bensley ('15, p. 17), writing of the food of this species, says it is a bottom feeding fish, subsisting ordinarily on mollusks and crustaceans, but is very destructive to the spawn of other species; and he tells of its abundance on shoals where whitefish, trout, and herring resort in the fall for spawning purposes. He says: "It also runs into rivers, to the foot of waterfalls in the early spring, feeding on the spawn of the doré, and afterwards spawns in the same situation. It is not infrequently seen swimming lazily about in the shallow water of the swamps in June during the spawning time of the Rock Bass and Black Bass, and on some occasions has been observed to enter the nests of these fishes, apparently with little resistance on the part of the occupants and leisurely to devour the contents." Bean ('03, p. 102) quotes D. Richardson as saying that the food found in stomachs he examined was chiefly soft insects, but in one he found fragments of a fresh-water shell. Kendall and Goldsborough ('08, p. 24) say: "The food is usually minute animal and vegetable organisms, though it does not reject larger objects. Young fish have been found in its stomach, and it feeds largely upon the eggs of other fish when it can get them." It is thus very evident that the Common Suckers have a much diversified fare, which undoubtedly accounts to a considerable extent for their wide range of habitat and abundance.

Smallwood ('18, p. 333) found plant remains, crustacean skeletons, sand, *Plumatella* and débris to have been eaten by this species at Lake Clear in the Adirondacks.

Ellis and Roe ('17, p. 69) give data on the destruction of eggs of Log Perch, *Percina caprodes*, by Common Suckers in Douglas Lake, Michigan. They would crowd into schools of Log Perch and devour their recently laid eggs. For nearly two weeks they were seen near these schools during the day. Fifteen of the suckers averaging nearly a foot in length were examined. All contained eggs of Log Perch, some sand, and little or no other material. From 23 to 1425 eggs were found in the various suckers. Pearse ('21, p. 263) reports on the food of two large Common Suckers nearly 20 inches long. He found them taking a variety of food, the most important being amphipods, little clams and insects. Greeley ('27, p. 57) examined two small Common Suckers, about 2½-6 inches long, from the Genesee System and found they had eaten mud, diatoms, filamentous algae and midge larvae.

Distribution Records. In June, 1916, young suckers were taken in shallow water as follows: No. 400, Froher Bay, 90 fish; No. 401, Billington Bay, 39; No. 403, Shackelton Point, 137; No. 406, Leete Island, 2; No. 422, Mathews Point, 37; No. 434, Norcross Point, 1; No. 459, Potter Bay, 8; No. 463, Potter Bay, 9; No. 470, Cleveland Bay, 2; No. 619, Lakeport Bay, 2; No. 627, Market.

In early July, 1916, the following collections containing young suckers from shallow waters were made: No. 475, Short Point Bay, 2; No. 498, Messenger Bay,

4272; No. 500, Lewis Point, 14; No. 501, Lewis Point, 1; No. 507, Upper South Bay, 1; No. 522, Frenchmen's Island, 47; No. 526, Maple Bay, 8; No. 529, Dunham's Island, 1; No. 543, Frenchman's Island, 1. In late July the following collections containing small suckers were made from shallow water: No. 550, Godfrey Point, 2; No. 585, Lower South Bay, 16; No. 605, Shaw's Bay, 1.

In September, 1915, only three collections containing small suckers were made in the lake: No. 76, Constantia, 1; No. 86, Paddygut Bay, 3; No. 100, Ladd's Bay, 23. Fall collections made in October, 1914 and 1916, including small suckers are as follows: No. 5, Lower South Bay, many; No. 305, Brewerton, 3; No. 413, Brewerton, 3.

In creeks connected with Oneida Lake we took small Common Suckers as follows: No. 75, Scriba Creek and Frederick Creek, 13 specimens; No. 81, Johnson Bay Creek, 1; No. 88, Chittenango Creek, 2; No. 516, Fish Creek, 1; No. 546, Chittenango Creek, 1; No. 593, North Bay Creek, 38; No. 621, Johnson's Bay Creek, 1.

We collected only one Common Sucker from deep water, No. 519, taken in a gill net set in 12 feet of water off Norcross Point. Some of those found dead were preserved. Some specimens were obtained from the market; they belong with collections Nos. 129, 345, 351, 486, 560.

Enemies and Disease. Lampreys attack this species in Oneida Lake, and many with scars were found dead; some of these were preserved (Nos. 75, 92, 93, 518, 614). Fowler ('06, p. 158) tells of suckers being bored into by lampreys (in all probability *Petromyzon marinus*), in New Jersey. They are undoubtedly also eaten in large numbers by black bass and other predacious fishes (Nash, '08, p. 29). One was found in the stomach of a Chain Pickerel taken at Johnson Bay, July 11, 1916. Hankinson ('16, p. 145) noticed Pike (*Esox lucius*) present in unusual numbers in the only part of a pond in the Whitefish Point region which was frequented by these suckers, and where they were abundant. Juday ('07, p. 166) found remains of this species in stomachs of Rainbow Trout, *Salmo irideus shasta*, in Colorado. Hankinson ('17, p. 326) once saw a water snake (*Natrix sipedon*) about four feet long capture a Common Sucker nine inches long, in a shallow, rapid part of a stream in Illinois. Fowler ('13, p. 14) found fragments of this species in a nest of a Kingfisher. Two (No. 31) were taken from the stomach of an American Merganser at Cranberry Lake in the Adirondacks, N. Y., August 21, 1915, by C. C. Adams. These fish were about 5 inches long. The eggs are evidently eaten by Black-nosed Dace and darters during the spawning time (Reighard, '20, p. 13).

Wilson ('04, p. 131) found a copepod *Argulus catostomi* attacking this species. Cooper ('20, p. 5) describes *Glaridacris catostomi* Cooper from this sucker found in Douglas Lake, Cheboygan County, Michigan. Fowler ('14, p. 350) records a large cestode, *Dibothrium ligula* Donnadieu, in a large sucker of this species. Larval trematodes were found in the eyes of Common Suckers from Douglas Lake, Michigan (LaRue and others, '26, p. 285; Butler, '19, p. 116). In a stream in Ohio, Osburn ('01, p. 10) found most individuals of this species attacked by leeches. Evermann and Clark ('20, Vol. 1, p. 295; Vol. 2, p. 79) note *Argulus catostomi* Dana and Herrick, and also leeches, on Common Suckers. We



Fig. 195. Broad low meadow shore of Oneida Lake at South Bay.



Fig. 196. *Castalia* zone and swamp shore of Three Mile Bay. July 3, 1916.



Fig. 197. Swamp shore and *Sagittaria* growths of Three Mile Bay. July 3, 1916.



Fig. 198. Details of swamp shore at Three Mile Bay. July 3, 1916.

obtained a specimen of a large argulid about a half inch long on a White Sucker, No. 594, found dead in Oneida Lake; and a smaller one was found on this species by A. G. Whitney, in Seneca River, in May, 1916. Leeches were attached to a dead fish (No. 591) found at Sylvan Beach. Some large cestode worms were found in two specimens (No. 1509) from North Pond, near Boonville, N. Y.; and several from two Common Suckers (No. 396 and 48) from Cranberry Lake. Reighard ('15, p. 225) notes the great mortality of the species in Douglas Lake, but thinks it due to starvation.

Economics. Considerable difference of opinion exists as to the edibility of this fish, but there appears to be but one well established objection to it, the many bones. From some bodies of water the flesh certainly has a very agreeable flavor. In Walnut Lake, Hankinson found them excellent in this respect, surpassing the Whitefish there. When taken from cold water the flesh is more palatable than if taken from warm water (Bean, '92, p. 29; '03, p. 102). Since these suckers spawn in cold streams in early spring, their flesh is then good, and they are very easily caught. Many are caught during this spring "run" in some places, and are salted and marketed, or used for home consumption. Mr. J. D. Black informed us that many used to be taken and salted at Brewerton and shipped to New York City. Taking them was then licensed, but now there is no legal way of getting these suckers in quantities from Oneida Lake. This abundant source of good food certainly should be made more available. By reducing the numbers of these fish in the lake an increase in Pike Perch, black bass and other game fish might result, since there is good evidence that eggs of these valuable species are destroyed by the suckers.

Angling. While this species appears to take the hook but rarely in lakes, it is sometimes taken in large enough numbers in this way in streams to make fishing for them an appreciable sport, especially when real game fish are absent. Worms are used as bait, and sometimes bits of crawfish. Forbes and Richardson ('09, p. 86), Kendall and Goldsborough ('08, p. 24), and Kendall ('18, p. 511) tell of the eagerness of this species to take bait in some localities amounting to annoyance to the anglers. They say also that these fishes have been caught on the spoon and on the artificial fly. A large sucker, they say, fights vigorously when hooked, and then succumbs. They consider the food of this species usually to be minute animal and vegetable organisms, but it also takes larger objects such as the eggs of other fish; and even young fish have been found in its alimentary canal. Evermann ('01, p. 339) states: "The young 3 or 4 inches in length are considered by many as being excellent bait for Black Bass and Wall-eyed Pike, while those a little larger are in demand when one goes trolling for Muskallunge or the Great Northern Pike. This sucker is fairly hardy and quite active, but not brightly colored." Greeley ('27, p. 57) writes that small specimens are used for bait for pike and pickerel, in lakes.

References. Adamstone, '24; Allen, '14; Baker, '16; Bean, '92, '03; Bensley, '15; Bigelow, '24; Butler, '16; Clemens, '23, '24; Colbert, '16; Cooper, '20; Culbertson, '03; Ellis and Roe, '17; Embury, '15; Evermann, '01; Forbes, '80, '86, '88, '88a; Forbes and Richardson, '09; Fowler, '06, '12, '13, '14; Goode, '03; Greeley, '27; Hankinson, '08, '16, '17, '20; Jordan and Evermann, '03; Hubbs and Creaser,

'24; Kendall and Goldsborough, '08, '09; LaRue, '16; Leathers, '11; Mavor, '15; Nash, '08; Osburn, '14; Pearse, '21; Reighard, '15, '20; Smith and Bean, '08; Stewart, '26; Wilson, '02, '04, '19.

Hypentelium nigricans LeSueur. HOG SUCKER, STONE-ROLLER, HAMMER-HEAD SUCKER. Three specimens of this sucker were found in the Oneida Lake region, one from Chittenango Creek and two from the Brewerton market. It is apparently scarce in the lake, yet its presence may easily be overlooked for it is difficult to capture by net and difficult to see in the water. It is a unique fish, having a very large head, expansive pectoral fins, and a comparatively small, distinctly tapered body which is blotched, making the fish very inconspicuous on the stony bottoms of streams. Goode ('03, p. 435) calls it a singular and almost conical form.

Breeding Habits and Life History. Little appears to be known of the breeding habits of this species. It habitually frequents the usual spawning places of our suckers, which are gravelly shallows of streams, so perhaps it does not change its habitat for breeding in this region. Forbes and Richardson ('09, p. 88) say that it ascends the swifter brooks in spring, doubtless to spawn. Wright and Allen ('13, p. 4) give the breeding place as shallows of swifter brooks, and the time as April to May. Bean ('02, p. 280) states that the spawning season is in the spring, and that the young are abundant in small creeks as well as in rivers. Reighard ('20, p. 21) notes that both sexes have pearl organs; and he found evidence of spawning on May 4, 1904, near Ann Arbor, when six or eight males were seen to group about one female, pressing close to her. No vibrations of the body were noted. Hankinson ('19, p. 136) made similar observations in a stream near Charleston, Illinois, where he saw two of these suckers, one chasing the other and finally the two settling and resting for some minutes with their sides applied; but at another time in the same stream there were bodily movements on the part of two apposed fish.

Habitat. The Hog Sucker has a very restricted habitat and is confined almost entirely to the swift clear water over a rocky bottom. It avoids warm and muddy water (Jordan and Evermann, '96, p. 181; Forbes and Richardson, '09, p. 87; Goode, '03, p. 435.) It rarely occurs in lakes (Forbes, '86, p. 105). In Winona Lake, Indiana, according to DeRyke ('22, p. 39), this sucker is usually found over a mud bottom.

Food. Forbes and Richardson ('09, p. 87) say: "It seeks its food in the more rapid parts of streams, pushing about the stones upon the bottom and sucking up the ooze and slime thus exposed, together with the insect larvae upon which it mainly depends for food. . . . It is, in short, a molluscan feeder which has become especially adapted to the search for insect larvae occurring in the rapid water under stones . . . more than half of the food of the specimens examined consisting of a single form (*Cacnis*) abundant under stones. A few aquatic larvae of a gnat (*Chironomus*) and some other insect remains, with an insignificant ration of small bivalve mollusks, were the other elements of its food." Reighard ('20, p. 20) describes the method of feeding as follows: "When not breeding it may often be seen feeding on the rapids of our brooks, creeks and smaller rivers. In feeding, the fish puts its snout under a stone and roots it up or thrusts it side-

wise. It then sucks up the slime between the stones and with it obtains immature insects." Evermann and Clark ('20, p. 295) found the stomachs of two specimens filled with mud and animal and vegetable remains. The food of nine specimens from Winona Lake, Indiana, was examined by DeRyke ('22, p. 39). Chironomus larvae were the principal food remains, while aquatic oligochaete worms, ephememerid nymphs, silt, sand and debris made up other material. Greeley ('27, p. 57) reports on the food of a young Hog Sucker nearly an inch long, as composed of 95% small crustaceans (*Chydorinae*) and 5% midge larvae; rotifers and diatoms formed a trace of the food.

Distribution Records. The two specimens (Nos. 360, 486) are from the Brewerton market, presented by Mr. H. N. Coville. Each is about a foot long. No. 365 includes 3 market specimens; No. 548 is a specimen taken by us about 2½ miles up Chittenango Creek, in 3 or 4 feet of fairly rapid water, over a rocky bottom. It is about a foot long. One young specimen (No. 4270) was taken at Sylvan Beach September 9, 1927.

Enemies and Disease. Our specimen No. 548, from Chittenango Creek, was nearly dead when taken, had a small injury on its belly, and may have been diseased.

Economic Relations. The Hog Sucker is of little economic value on account of its small size, many bones, and the difficulty of capturing it in numbers. Evermann ('01, p. 340) says they are used to some extent as bait in still-fishing, but are not of much value. They live well on the hook and are pretty active, but they are too dull in color and too prone to seek the bottom.

References. Bean, '02; Butler, '19; DeRyke, '22; Evermann, '01; Forbes, '86; Forbes and Richardson, '09; Goode, '03; Greeley, '27; Hankinson, '21; Jordan and Evermann, '06; LaRue and others, '26; Reighard, '20; Richardson, '09; Wright and Allen, '13.

***Erimyzon sucetta oblongus* (Mitchill).** CHUB SUCKER. (See Figure 199.) This is largely a stream fish. It is not abundant and probably its main value, aside from its use as bait, lies in its serving as food for other more valuable fish. It may be distinguished from other suckers of Oneida Lake and vicinity by the absence of the lateral line. In the water it appears somewhat like a perch with dark vertical bars on its sides, but the single dorsal fin and inferior mouth will readily distinguish it from that fish. The young lack these bars but have a conspicuous, black, lateral band on each side.

Breeding Habits and Life History. Very little is recorded on the breeding habits of this fish. Forbes and Richardson ('09, p. 82) note that, "In ordinary seasons it spawns in central Illinois in April and May. Ripe females were taken at Havana April 10, 1899, and females with ripe ovaries from March 20 to April 15." Wright and Allen ('13, p. 4) give the breeding season in small streams at Ithaca, N. Y., as April to May 15. The males in spring usually show three large tubercles on each side of the snout, and the anal rays are tuberculated; these characters only appear in males over five inches, and until the maximum size (eleven inches) is attained, according to Fowler ('12, p. 475). One of our market specimens (No. 365) from Brewerton, taken in May, agrees with Fowler's description. It is about 10 inches long.

Fowler ('06, p. 162) mentions its migratory habit, similar to that of the Common Sucker: "It wanders up the streams in much the same way during the spring, running in schools." Richardson ('13, p. 410) records that in Illinois "The fry of this species, $\frac{3}{4}$ to $1\frac{1}{4}$ inch long, were abundant in River Marshes in late May and early June of 1910 and 1911. The fry swim in schools of fifty to a hundred or less, at about the same level as bass fry, and their coloration, owing particularly to the black side-stripe, is such that they are not always readily distinguished at first glance from fry of large-mouthed bass." Bean ('92, p. 28) states that the young are "often found in the shelter of water-lilies and other aquatic plants close to brackish water." Hankinson ('08, p. 208) found in southern Michigan young fish, less than an inch long, on June 16.

The noise produced by the Chub Sucker has been described by Abbott ('90, p. 441). "The *mullet* or *chub sucker*," he writes, "is another example of those dull-colored, nocturnal fishes that frequent streams with muddy beds thickly overgrown with water-plants, and which have the power of audibly forcing air from their bodies. In April, with a noticeable deepening of their coloration, there is increased activity in every movement, and, wholly unlike their actions by day, at night they swim quite near the surface, and utter a single prolonged note, accompanied by a discharge of air-bubbles. They appear to project their jaws just above the water, and force the air from beneath their gill-covers immediately below the surface, as there are two parallel streams of bubbles. When seen in the moonlight, these bubbles appear like minute silver beads. Swimming in this way, the mullet will often proceed a hundred yards, uttering their peculiar 'calls' four or five times while passing over that distance."

Habitat. Our specimens have been taken from both rapid and sluggish streams and from shallow water in Oneida Lake; the source of our market specimens is unknown. Bean ('92, p. 27) records this sucker from "slow muddy streams" in Pennsylvania; and Hankinson ('13, p. 27) states that it prefers deep pools in small creeks and is not often taken in the larger streams. Forbes and Richardson ('09, p. 82) say: "It is essentially a creek species, occurring proportionately five times as frequently in our collections from creeks as from rivers, large or small, and eight times as frequently as from lakes and ponds." Evermann ('01, p. 341) remarks, "It inhabits the smaller, quiet creeks and the smaller lakes, preferring cool water and muck bottom." "When young," according to Abbott ('90, p. 424), "they associate with whatever cyprinoids happen to be wandering in the same waters, their habits being essentially the same. Unlike the other four 'suckers' I have mentioned this fish, when young, thrives well in perfectly quiet water, and seems to suffer no inconvenience when the July sun warms the still ponds to such a degree that all the other fishes leave in disgust, and seek the babbling springs, or bury themselves in the mud. The adult mullet differ from the young of one or two summers, in being strictly nocturnal. Throughout the day they remain quietly at rest among the weeds in the bottom of the ditch, but on the approach of darkness they are full of activity, and not only wander to and fro through the water, but come to the surface and even leap above it. The change is very great. It is during this excited state, or throughout the night, that these fish utter audible sounds."



Fig. 199. Chub Sucker (*Erimyzon sucetta oblongus*).



Fig. 200. Channel Cat (*Ictalurus punctatus*).



Fig. 201. Mud Minnow (*Umbra limi*).



Fig. 202. Brook Stickleback (*Eucalia inconstans*)

Food. The food of the Chub Sucker, according to Bean ('92, p. 28), consists of minute crustaceans, insect larvae and aquatic plants. Hankinson ('10, p. 30) found that some Chub Suckers had fed entirely upon soil and diatoms, and others upon entomostracans and Chironomus larvae. Forbes and Richardson ('09, p. 82) say that the Chub Sucker is a bottom feeder and has the habit of supporting itself on the bottom, like the darter, by means of its paired fins.

Distribution Records. Our collections of the Chub Sucker are the following: No. 75, from Scriba Creek, one $1\frac{1}{2}$ and another 3 inches long, August 31, 1915; No. 87, from small brook, protectors' camp, Chittenango Creek, one $1\frac{3}{4}$ and another 2 inches long, September 2, 1915; No. 120, from Big Bay Shoal, near Belknap's Landing, one fish $2\frac{1}{4}$ inches long, September 7, 1915; No. 142, from Frederick Creek, between the railway track and the hatchery, 3 specimens, one $1\frac{1}{2}$ inches long, the second about 4 inches, and the third $7\frac{1}{4}$ inches long, September 8, 1915; Nos. 365, 486, 601 from fish market at Brewerton.

Enemies and Disease. We have found little recorded on enemies of the Chub Sucker. Hankinson ('08, p. 208) records the finding of one in the stomach of a Large-mouthed Black Bass. Marshall and Gilbert ('05, p. 517) record a few acanthocephalans from the intestine of the Chub Sucker. Wilson ('02, pp. 646, 709; '16, p. 339) records the parasitic copepod, *Argulus catostomi* Dana and Herrick, as attached to the gill cavity, fins, and outer surface of a Chub Sucker. A sporozoan, *Myxobolus oblongus* Gurley, was found encysted beneath the skin on the head or near it (l.c., pp. 101, 234-237). All of our large market specimens (Nos. 265, 486, 601) show black dots in the skin and on the fins and some specimens are rather heavily infested.

Economics and Angling. As a food fish this species is not of much value and it is marketed with the "culls." Formerly it was marketed in New York City in the late autumn. Evermann ('01, p. 341) states that "It is not much valued as a food fish." Bean ('92, p. 28) remarks, "It is very tenacious of life and is a ready biter, but has little value for food"; and Forbes and Richardson ('09, p. 82) state, "This fish bites readily at a small hook, but its flesh is bony and without flavor, and owing to its small size the species has no commercial value."

References. Abbott, '90; Allen, '13; Bean, '92; Fowler, '06, '12; Gurley, '92; Evermann, '01; Forbes and Richardson, '09; Hankinson, '10, '13; Marshall and Gilbert, '05; Richardson, '13; Wilson, '02, '16; Wright and Allen, '13.

Moxostoma aureolum (LeSueur). COMMON RED-HORSE, MULLET. This sucker is recorded from Oneida Lake by DeKay ('42, p. 198), who called it the Oneida Sucker and considered it common there, but our only record is from a market specimen said to have come from the Lake. It is reported abundant in spring in the Oneida River at Brewerton; possibly there are many in Oneida Lake.

Breeding Habits and Life History. It breeds on riffles of streams in April and May (Wright and Allen, '13, p. 4; Forbes and Richardson, '09, p. 91). Young fish frequent small streams in large numbers, and it is surprising that none has been taken in some of our large stream collections. Nash ('08, p. 32) says: "In the early spring, as soon as the ice moves out, the Mullet run up the streams to spawn, forcing their way through the swiftest torrents in order to reach the gravelly beds upon which the ova are deposited. After spawning they

retire to deep water." McCormick ('92, p. 15) believes the Red-horse spawns in spring as soon as the water is a little warmer; and says that they spawn at night on the riffles, and often may be seen lying in clusters of five or six, obliquely across the current. Reighard ('20, p. 15) gives detailed notes on the life history of the species. In Michigan he found them spawning on gravel of rapids, in conditions similar to those used by the Common Sucker, but they seem to breed only in the larger streams, thirty or forty feet in width or larger. The adults of the two sexes are similar, but the males have pearl organs. Two males crowd on each side of a female during the spawning act. The position is maintained but for an instant, during which there are spawning vibrations as in the Common Sucker. Evermann and Clark ('20, Vol. 1, p. 339) say: "When the warm days of spring return these fish leave the deeper water and run up stream into the shallow, swifter portions. The spring run of the suckers was, in early days, one of the phenomena in Indiana and Illinois which never failed to attract the attention and excite the interest of those who were at all observing."

Habitat. Forbes and Richardson ('09, p. 91) found it in Illinois commonest in creeks and smaller rivers and to some extent in lakes where it showed a preference for swiftly flowing streams and an avoidance of muddy bottoms. Jordan ('82, p. 828) says it is very common in Lake Erie, and Evermann ('01, p. 342), that it occurs in most streams and large lakes within its range. Shelford ('13, p. 119) found it confined to the lower part of Hickory Creek in Illinois, where the stream was largest and with good riffles. It appears to need good, pure water, for it dies in an aquarium if the water is the least bit impure, and it succumbs also to any impurities in its natural environment (l.c., p. 140).

Food. Forbes ('88a, p. 443; Baker, '16, p. 167) found twelve examples of this species feeding upon mollusks, larvae of *Chironomus*, and other mud-inhabiting species, *Entomostraca*, some vegetable material (chiefly *Wolffia* and *Chara*), filamentous algae, and other miscellaneous material. Adamstone ('24, p. 79) describes the food for four individuals of this species found in Lake Nipigon. May-fly nymphs and several kinds of aquatic insects had been eaten; also Mollusks and dipterous larvae of Chironomidae and Tabanidae. Clemens ('24, p. 110) gives records in tabular form of the food of four Common Red-horse specimens averaging about 20 inches in length. Ephemerid nymphs were abundant in all; and there were many other invertebrates, including entomostracans, chironomids, oligochaete worms, mollusks and protozoans; and some moss was noted. Greeley ('27, p. 58) found the food of a nine-inch fish to be mud containing filaments of algae, many diatoms, eight chironomid larvae and some *Cyclops*.

Distribution Records. DeKay ('42, p. 198) states that it is common in Oneida Lake. No. 351, from a market at Brewerton obtained April 24, 1915, was said to be from Oneida Lake. The fish measured about 18 inches in length. One (No. 1511) was caught in Seneca River near Baldwinsville, some twelve miles southwest of Oneida, on October 1, 1916, by L. L. Rother. Mr. W. A. Dence reports Red-horse, either one or both species, to be common in the lake.

Enemies and Disease. DeKay ('42, p. 201, *Catostomus aureolus*) mentions that Lake Erie specimens obtained in August and September were full of worms. Smith ('74, p. 665) tells of a crustacean parasite, *Lernaeocera catostomi* Kroyer,

found upon *Catostomus macrolepidotus*, which was in all probability this species of sucker, living in the Mississippi River at St. Louis.

Economic Relations. This fish is of little value as food and is commonly considered a coarse or cull fish. The flesh is very bony. When "running" in rivers in the spring, however, they are often taken on hooks, and if no better fish are to be had they are utilized. Jordan and Evermann ('03, p. 63) remark that it is held in considerable esteem in the Upper Mississippi Valley by farmers, who are in the habit of snaring, seining, or catching them in traps in great numbers in the spring, and salting them for winter use. According to Evermann ('01, p. 342), it is a food-fish of considerable importance in Lakes Ontario and Erie, where it is taken chiefly in pound-nets or with haul seines. He further says (l.c.): "The young of 2-4 inches are regarded as pretty fair bait for large bass, Pickerel, Wall-eyed Pike and Muskallunge. They are hardy and live well on the hook, and their white or silvery coloration makes them a fairly good trolling bait. According to Nash ('08, p. 32), they take bait readily, frequently weigh four or five pounds, and afford good sport in the swift waters they frequent.

References. Adamstone, '24; Baker, '16; Clemens and others, '24; DeKay, '42; Evermann, '01; Forbes, '88a; Forbes and Richardson, '09; Greeley, '27; Jordan, '82; Jordan and Evermann, '03; McCormick, '92; Nash, '08; Reighard, '20; Shelford, '13; Smith, '74; Wright and Allen, '09, '13.

***Moxostoma lesueurii* (Richardson).** SHORT-HEADED RED-HORSE. This sucker is given a place in the list of Oneida Lake fish on the basis of a specimen purchased November 17, 1915. The species resembles closely the Common Red-horse, but its head is smaller and more pointed.

Habitat. Forbes and Richardson ('09, p. 92) found it especially abundant in small rivers, but also in large rivers, creeks and lakes; it avoids clear water and swiftly flowing streams more than the Common Red-horse. We have found nothing recorded on the breeding habits of this species. Greeley ('27, p. 58), in writing of the fish of the Genesee system in New York State, says this species is moderately common and found in large warm streams, often occurring with *M. aureolum*.

Food. Baker ('16, p. 168) examined the specimen mentioned above, but at that time it was wrongly identified as *Moxostoma aureolum*, so that Baker's data are given under that species. He found its intestine to contain a small quantity of material in an advanced state of digestion, but could identify 14 chironomid larvae, 1 *Hexagenia* nymph, and a small amount of filamentous algae. Forbes ('88a, p. 444) records the food of specimens named *Moxostoma aureolum* but which evidently represent *lesueurii*. (See Forbes and Richardson, '09, p. 91.) Forbes says it takes food almost identical with that of the Common Red-horse, called by him *Moxostoma macrolepidotum* LeSueur, as one may judge from the six Illinois specimens examined. The food was practically all animal matter, about one-half mollusks; the insects were mostly *Chironomus* larvae and pupae.

Distribution Records. An Oneida Lake specimen (No. 327) bought in a Syracuse market.

Economic Relations. It appears to have no greater food value than the Common Red-horse with which it is frequently seen on the anglers string in

regions where both occur. As it is abundant in Lake Erie (Jordan and Evermann, '96, p. 196) doubtless many are caught in pound-nets there and sold. Greeley ('27, p. 58) considers this as good a food fish as the Common Red-horse, but not becoming so large.

References. Baker, '16; Forbes, '88a; Forbes and Richardson, '09; Greeley, '27; Jordan and Evermann, '96.

Cyprinus carpio Linnaeus. **CARP.** The Carp (Fig. 188) is a well known exotic species that has become abundant in Oneida Lake, as it has in other waters suitable for it in the United States. It is a native of China (Forbes and Richardson, '09, p. 105) and has been widely introduced on account of its being reared in ponds and for its value as food. In the United States, however, it is not generally esteemed, chiefly because of the numerous better varieties of native fish to be had, and the ease with which meat and other sources of food may be obtained. Embury ('15, p. 214) explains the popularity of the Carp in European countries as follows: "Necessity no doubt has been the primary cause of the development of this industry. The supply of fish in the public waters of these countries was exhausted long ago, and, since sufficient meat could not be raised on land fully to supply the increasing demand, it became necessary to transform waste lands into water areas and to stock them with fish." With the increase in population in the United States, Carp raising is likely to become an important industry as in Europe. In New York City there is a large demand for Carp as table fish. In Oneida Lake it is considered a pest, largely because there has been no satisfactory legal method of reducing the excessive numbers, and in part because of prejudice. A comprehensive study of the species has been started by the Conservation Commission.

The Carp was introduced into the United States about 1876. Smiley ('81, p. 943) writes that it was imported from Germany, and that some were placed by Hessel in Druid Hill Park, Baltimore, May 26, 1876. Forbes and Richardson ('09, p. 105) state that the Carp was introduced into Europe about 1227, and successfully introduced in the United States in 1877 by Hessel. Linnaeus (Bean, '02, p. 292) states that Carp were introduced into England in 1600. DeKay is given as authority for the statement that the fish was brought into New York State in 1831. Reed and Wright ('09, p. 396) say the fish has been known to inhabit Cayuga Lake since 1889. It must have increased rapidly there for Hankinson recalls its extreme abundance in that lake as early as 1898. Koelz ('26, p. 598) says that it escaped from private ponds into Lake Erie in 1883. Cole ('05, p. 597) reports none in the Great Lakes prior to 1879 and gives (p. 633) an interesting account of its introduction into the United States, including reasons for its failure to become generally popular, which are as follows: (1) People expected too much from the fish; (2) the muddy flavor of its flesh, due to capture at wrong seasons, was extensively advertised and developed prejudices against the fish for table use; (3) there was a lack of knowledge of proper methods of preparing the fish. Cole (l.c., p. 547) writes of the enthusiasm about 1880 attending the distribution of the Carp in the United States by the Fish Commission. There was an interest in getting something for nothing and, "Here seemed to be an opportunity to have a perpetual supply of fresh fish for anyone who had land with any kind of a mud hole on it that would hold a few bucketfuls of water. Accordingly applications

for Carp piled in, and were filled as soon as possible. As a result of ignorance and neglect, a large proportion of these fish or their offspring were soon undoubtedly in the public waters—largely from the breaking of dams of improperly constructed ponds, and two years later (in 1883) came reports of their being taken in considerable numbers by fishermen in rivers and lakes.”

Smiley ('81) lists the places of distribution of Carp by the U. S. Fish Commission, including those in New York State (p. 971). In the Illinois River, Carp have made a remarkable increase (Forbes and Richardson, '19, p. 149), where from 1894 to 1897 they increased from 9.6 per cent to 56.6 per cent of the total catch.

Smith ('96, p. 393) says that at that time Carp were present in all the states of the Pacific and Rocky Mountain region and that they were sent to California in 1879 and to Nevada in 1881. Later, Smith ('07, p. 105) states that Carp were found in all states and territories of the United States except Alaska.

Taking the Carp the world over, it seems to be a very valuable fish to Man. Taylor ('17, p. 1) considered it the most valuable of fresh water fishes. Dr. Hugh M. Smith ('10, p. 1406), makes the following statement: “The consumption of Carp is certainly destined to increase greatly; but even if the catch reaches no higher point the introduction of the Carp into the United States will remain the leading achievement in fish acclimatization in recent times, and, with the exception of the original introduction of the same fish into Europe from Asia, the most important the world has known.” Of course this is from the standpoint of a cheap food fish.

Breeding Habits and Life History. Carp appear to spawn in the shallow marsh waters bordering Oneida Lake, in May and early June, according to Mr. W. H. Weston, State Game Protector; but on July 2, 1916, many large carp were seen by Mr. Becker, our field helper. They were splashing in the shallows bordering the lake at Walnut Point. Residents near Billington Bay informed us that the marshy ground bordering the lake (Fig. 193) was used as a spawning ground for Carp, and that in early summer large numbers of large fish school there, with backs out of water, creating considerable disturbance in the water with their noisy splashings. The region appeared to us to be typical of described spawning grounds of the species. Protector J. D. Black has observed Carp splashing in the flooded pastures and meadows at the mouth of Chittenango Creek; places not frequented by breeding bass. Bean ('03, p. 168) gives the spawning time as May to August; and it is likely that the season is mostly past by late spring and early summer, in New York State (Wright and Allen, '13, p. 5; Allen, '13, p. 57). Farther south Carp begin spawning earlier. Richardson ('13, p. 390) found them spawning near Havana, Illinois, April 10. Cole ('05, p. 573) gives the spawning time as April in southern United States to California, and May and June in northern states. Mr. W. A. Dence saw several large Carp well inshore in Maple Bay, on June 13, 1927, and the water here was very roily. On the same day he likewise found several in a small creek entering Chittenango Creek a short distance from the lake. The water here was likewise roily.

In spawning, a female is accompanied closely by several males (Forbes and Richardson, '09, p. 107; Gill, '05, p. 206; Cole, '05, p. 575; Seeley, '86, p. 98).

They swim slowly about, often with their dorsal fins and sometimes with portions of their backs out of water (Cole, '05, p. 575). Carp spawn when two years of age, under proper water and food conditions, according to Leach ('19, p. 13), and are then from 16 to 18 inches long. Warm days with a light south wind seem to be most often selected by Carp for spawning, according to Richardson ('13, p. 390); and Cole ('05, p. 575) says that they apparently spawn most frequently in the early morning hours.

Shallow weedy swamps are favorite spawning grounds. Such situations were found by Cole ('05, p. 575) along the Sandusky River, who described them as follows: "Shallow water, one to two feet deep, and pretty well grown up with aquatic grasses, sedges, and flags, but with numerous open places from a few feet to a few rods in diameter, where the vegetation was not so abundant. The bottom was fairly solid, being composed of the roots of the plants and much dead grass." The region about Billington Bay of Oneida Lake (Fig. 193), where Carp were said to spawn, was similar to the breeding habitat described by Cole. Sometimes they spawn in water as deep as 5.5 feet, according to Richardson ('13, p. 397). The eggs are scattered over the vegetation of the shallow breeding habitat. Richardson (p. 391) noted 100-2500 Carp eggs to a square yard of bottom on their breeding grounds. Their eggs are adhesive and cling to the plant surfaces. Evidently many are lost through falling in loose soil but this loss is negligible considering the number produced by such a prolific species. Gill ('05, p. 206) records 2,000,000 eggs in a Carp weighing 16.5 pounds. The ovaries weighed 5.5 pounds. According to Leach ('19, p. 14) the number of eggs deposited by a female during an entire season will vary from 300,000 to 700,000 according to size, but not more than 400 to 500 are deposited at one time.

The eggs hatch in about five to twelve days, dependent on the water temperature (Cole, '05, p. 578). The fish matures in two or three years (l.c., p. 573). During the first year they may become about six to eight inches long (Forbes and Richardson, '09, p. 107; Embury, '15, p. 227). Leach ('19, p. 16) gives the following data as to size at different ages:

1 year,	1/2 pound,	length	9 inches.
2 "	1 1/8 "	"	12 "
3 "	2 1/4 "	"	15 "
4 "	5 1/2 "	"	20 "

W. A. Dence of the Roosevelt Station staff took young Carp in late August from a tributary of Oneida River, which ranged from about 2 to 2 1/2 inches in length. Gill ('05, p. 207), however, says that the fish reach a pound or more the first year, with abundant food. Bean ('02, p. 290) tells of a growth to 23 inches eleven months after planting. The maximum size of the species is large. Nichols and Heilner ('20, p. 1) give this as 90 pounds for a fish taken in Switzerland about 1825. The largest Carp noted by Cole in his extensive studies of the species in the Great Lakes was twenty pounds (Cole, '05, p. 535). The Danube has a record of one weighing 67 pounds (Bean, '02, p. 290). Smith ('07, p. 106) says they become as large as 40 pounds in the United States. Mr. Dence has been informed by fishermen that the average individual size in the many tons of Carp taken from Oneida Lake and put on the market in 1927, was about eight pounds, and the largest taken weighed 33 pounds.

Habitat. The Carp has a wide range of conditions under which it lives. It can endure extremes of temperature (Cole, '05, p. 563; Gill, '05, p. 304) and can live out of water for a considerable time. Its favorite feeding habitat appears to be shallow, moderately warm water where there is considerable vegetation and muddy bottom, with nearby deep places for retreat from danger or for winter quarters (Tracy, '10, p. 69; Forbes and Richardson, '09, p. 106; Cole, '05, p. 552). In feeding, these fish often keep the water turbid; and a continued muddiness of some shoal can only be accounted for by the presence of Carp rooting among aquatic plants. Cole ('05, p. 549) found extensive favorable situations for Carp in the shallow western portion of the Lake Erie, and notes their abundance there among rushes (l.c., p. 551). River mouths choked with vegetation (l.c., p. 550) form good habitats for Carp. Contaminated water of streams does not appear to affect it (Forbes and Richardson, '09, p. 106). Hankinson finds it abundant, thriving, and reaching large size in the Huron River below Ann Arbor, where the water is contaminated by sewage and contains liquid wastes from paper mills. Carp will also enter brackish waters (Meek, '16, p. 178; Cole, '05, p. 553). Oneida Lake fishermen, however, told Mr. Dence that Carp stay mostly in the clearer water, and are taken chiefly where the depth is six to eight feet; and that they enter the shallow, fouler waters of the lake only at breeding time. Carp become torpid and cease feeding in winter and have a true hibernation, according to Cole ('05, p. 561) and Seeley ('86, p. 97). Smiley ('83, p. 244) says they hibernate in ponds, but in lakes where deep water is available they move into this for the winter (Cole, '05, p. 556). Leach ('19, p. 17) describes their method of hibernation. He says: "At the approach of winter weather the Carp, in groups of 50 to 100, form cavities in the mud in the deeper portions of the pond and arrange themselves in concentric circles in these hollows, where they remain until spring, their heads huddled together, the posterior portion of the bodies raised and held immovable and the gills scarcely lifted in breathing. Though the fish take practically no food during the period of hibernation—extending roughly, from October to the end of March—they do not lose in weight."

We saw very few Carp in Oneida Lake in 1915-16, when we did most of our continuous field work and studied the shallows extensively, but their concentration on certain shallows at breeding time made their presence in the lake evident. It is said that they remain mostly in water more than forty feet in depth in the lake, but undoubtedly they come to the shallows to feed.

Food and Feeding. Carp feed on a great variety of food and are considered to be omnivorous by Forbes and Richardson ('09, p. 106). These authors note that they take principally vegetable matter, but also insect larvae, crustaceans, mollusks and other small aquatic animals; and they often while feeding (l.c.) pull up roots of tender aquatic plants. Cole ('05, p. 564) concludes that the species is omnivorous and that there is no food substance which it will not eat, but he does not consider it predacious. He tells of their feeding like pigs, rooting and splashing in shallow water (p. 565). Sometimes they feed from water plants at the surface (l.c.), and when thus feeding they make a sucking sound. Tracy ('10, p. 70) also notes such surface feeding. Carp appear to take food at all times of the day (Cole, '05, p. 573); but they eat little if at all in the winter (Forbes and

Richardson, '09, p. 106). Leach ('19, p. 16) considers the natural food to be mostly vegetation, though some animal matter is taken, such as larvae of insects. The Carp, he says, is not cannibalistic in habits but it will often consume its own eggs.

Analyses of contents of Carp enterons confirm the conclusion that the fish is omnivorous. Cole ('05, pp. 569-573) gives the results of the examination of 33 fish, in which he found that both vegetable and animal food had been taken in large amounts. Of the former, stonewort, or *Chara* seemed important, the fish evidently taking large amounts of this plant if it takes it at all. But the Carp also had fed upon roots, leaves, cortex and fibres of water plants, sedges, algae (*Spirogyra* and diatoms). The animal food was composed of insects (ephemerids, beetles, chironomids, caddisflies), crustaceans (amphipods, entomostracans), worms, protozoans, and mollusks. Whitefish eggs were found in two specimens (p. 572) taken in Lake Erie, in November, near Port Clinton, Ohio, although only one egg was actually identified from each fish.

Seeley ('86, p. 97), in discussing the Carp in Europe, says it subsists on algae, young shoots, water plants, decomposing plant remains, mud rich in organisms, including insects, and worms; and he notes that it becomes fat wherever droppings of animals, especially those of sheep, occur. Bean ('03, p. 169) informs us that it will eat lettuce and cabbage, seeds of water plants, such as water lilies, wild rice and water oats; and he also notes its insectivorous diet. Hunt ('12, pp. 190-191) found that a large Carp had eaten corn, oats, wheat, worms (including earthworms), crayfish and hellgrammites (*Corydalis*). Furthermore he found them feeding upon mussels, some of which were still alive in the Carp's intestines (p. 191). He considers that Carp are one of the causes of the scarcity of these mollusks in some regions. Garman ('91, p. 144) found seeds of elms, ragweed, smartweed (*Polygonum*) and mollusks (*Spacrium*, *Physa*, *Lioplax*) eaten by a Carp.

Baker ('16, p. 170) states that in addition to plants, insect larvae, crustaceans, etc., Carp feed upon molluscs. This, he says (p. 214), amounts to 15% of the food eaten.

Dyche ('14, p. 128) gives results of examining over 1200 Carp in food studies. The vegetable matter was corn, wheat, oats, kafir corn, seeds of elm, smartweed, foxtail grass, sourdock and sticktight—one stomach alone containing from a thousand to five thousand weed seeds of various kinds. He found no fish among the stomach contents; but he has seen Carp taking dead minnows, although making no effort to get live ones, even when they were abundant and the Carp were hungry. He found the Carp to be fond of Graham bread, boiled potatoes, and cheese (p. 129), and noted their habit of sucking up pond scums and "blowing" out from their mouths material they did not want.

The most precise quantitative studies of the food of the Carp appear to have been made by Pearse. He ('18, p. 258) examined the enterons of 42 fish from lakes near Madison, Wisconsin. He found the following contents: Insect larvae, 39.7 per cent; pupae, 6.8 per cent; adult insects, 3.5 per cent; mites, 1.8 per cent; amphipods, 6.9 per cent; entomostracans, 20.9 per cent; snails, 6.9 per cent; oligochaete worms, 2.8 per cent; rotifers, 1.1 per cent; and traces of protozoans and

algae. The fish were of all ages, measuring 1.5-18.5 inches. The first food taken by the young Carp was insects and rotifers, insect larvae were taken after the first few weeks, and vegetable matter was taken by the adult, omnivorous specimens. Pearse ('21a, p. 34) analyzed the food of the two small Carp 2 inches long, from Lake Pepin, Wisconsin. This food was chironomid larvae, 7.5 per cent; beetle larvae, 5 per cent; chironomid pupae, 50 per cent; *Cyclops*, 3.5 per cent; ostracods, 5 per cent. A large specimen from Lake Michigan, 24 inches long, contained (l.c., p. 42) chironomid larvae, 15 per cent; crayfish, 20 per cent; *Eurycerus*, 20 per cent; ostracods, 2 per cent; *Daphnia*, 2 per cent; caddis-worms, 1 per cent; Sphaeriidae, 15 per cent; plants, 5 per cent; sediment, 20 per cent. Pearse (l.c., p. 58) considers the Carp as the principal mussel eating fish in Lake Pepin, along with the Sheephead (*Aplodinotus grunniens*).

Greeley ('27, p. 56) reports on the food of 12 young Carp from Casadaga Creek of the Genesee System, New York State. These fish were under three inches in length, and had eaten entomostracans, dipterous insects in all stages, Zygoptera, snails, rotifers, and algae. He also examined the food of a 4 $\frac{3}{8}$ inch Carp from Cayuga Lake, New York, and found snails, chironomid larvae, entomostracans, caddis larvae, diatoms and desmids. Gill ('05, p. 206) notes the food of the young to be rotifers, copepods, and algae. Two carp measuring 57-65 mm in length caught by W. A. Dence in a tributary of the Oneida River, in late August, 1927, contained the remains of small snails.

Distribution Records. The following Oneida Lake specimens of Carp were obtained by us: Ladd's Bay, one found dead, No. 104; Chittenango Creek, collected by J. D. Black, No. 570; Dry Land Point, taken nearby in trap net by Pratt and Baker, two fish, No. 1205 and No. 1216; market specimens from H. N. Coville, reported from Oneida Lake, Nos. 359, 399, 618, 627, 628; market specimen from Oneida Lake, according to Samuel Rebeck, No. 327.

Enemies and Disease. Carp appear to have few enemies in our waters, which is partly due to their wary nature, and their avoidance of clear shallow waters. The muddy waters which they produce on shallows while feeding also doubtless serve to protect them. During the spawning time, however, they or their eggs are preyed upon by certain enemies. Richardson ('13, p. 402) found Garpike (*Lepisosteus*), grass pike (*Esox*) and bass on the spawning ground of the Carp. Smiley ('83, p. 246) reports turtles and snakes eating them. Nichols ('13, p. 8) quotes Warren as mentioning loons as enemies of Carp, mergansers as eating the species in reservoirs (p. 9), and Fishhawks taking them on the Delaware River (p. 14). Bartlett ('10, p. 152) says bass eat Carp extensively. Annin ('98, p. 199) records 78 small Carp from the stomach of a Night Heron. Forbes ('88b, p. 11) found Carp in stomachs of *Esox lucius* and *Ania calva*. Water bugs such as *Belostoma*, *Ranatra*, *Nepa* and *Notonecta* have been known to destroy small Carp in ponds, according to Dimmock (see Cole, '05, p. 583). Frogs and toads are considered enemies of Carp by Leach ('19, p. 13), who recommends that Carp ponds be enclosed with wire netting to prevent the entrance of these animals. Wetmore ('24) notes that Carp have been found in stomachs of the Western Grebe (p. 6), Horned Grebe (p. 11) and Pied-billed Grebe (p. 20).

Perhaps the worst enemies of the Carp are the animals that eat their eggs, which are scattered over vegetation in shallow water, for this is the natural feeding ground of numerous minnows and other small fishes. However the abundance of eggs laid by the Carp makes the species highly successful notwithstanding the depredations of its enemies. Smiley ('83, p. 246) also notes this destructiveness to Carp eggs by minnows, including goldfish, and Jordan ('05, Vol. 2, p. 170) writes that catfish, sunfish, and pike prey upon the eggs. Ellis ('14, p. 35) says the young Carp are eaten by bass, crappies, and sunfish, as well as by snakes and aquatic birds; he notes an instance where a Carp about seven inches long was taken from the stomach of an American Merganser. Richardson ('13, p. 404) considers bass to be very destructive to Carp fry in the backwaters of the Illinois River. Lampreys are frequently found attached to Carp in Oneida Lake, according to reliable testimony from fishermen, obtained by W. A. Dence. A large specimen in our collection (No. 104) was found dead in Ladd's Bay. It had two deep lamprey scars. Dence has frequently noticed large dead Carp about the shores of Oneida Lake, and in April, 1927, he found a dozen or more dead specimens, weighing 10 to 20 pounds, near the mouth of Chittenango Creek; and fully as many more about the shore of Maple Bay. Three large fish representing about 40 pounds of flesh were found in one heap and photographed as found. A commercial fisherman who has netted Carp for several years states that this is not peculiar to Oneida Lake. He had noticed that a decided bloating precedes the death of the fish, which he believes is caused by the retention of spawn; but this explanation does not seem plausible. Disease producing parasites were found to be uncommon by Cole ('05, p. 579) who examined Carp from waters of the Great Lake region. It seemed to him (p. 581) that in Europe the Carp is much less immune to parasites and diseases than in North America. Dyche ('14, p. 126) found the flesh practically free from parasites which are more or less common in many other fishes, especially the kinds that are embedded in the flesh. The following notes have been obtained from literature on the parasites of the Carp:

BACTERIA

Bean ('07, p. 221) tells of the red plague (*Bacterium cyprinicida*) forming vesicles under the skin of Carp.

FUNGI

Cole ('05, p. 580) notes *Saprolegnia* infesting Carp, and Seeley ('86, p. 99) describes "mossy growths" on the head. The eggs in the shallow water spawning places are attacked by a mold, according to Richardson ('14, p. 404).

PROTOZOA

Gurley ('94, p. 101) records *Myxosporidea* or psorosperms on Carp.

TREMATODE WORMS

Trematoda dujardianus Dies, Stiles and Hassall, '08, p. 31.

T. isosporum Loos, l.c., p. 44; *T. longicollis* Froelich, l.c., p. 49; *T. midius* Kath., l.c., p. 52; *T. mollis* Wedl., l.c., p. 54; *Diplostomum* sp., Pearse, '24, p. 172.

ACANTHOCEPHALA

Echinorhynchus sp., Cole, '05, p. 579; *E. thecatus* Linton, Van Cleave, '19, pp. 232, 236; *Pomphorhynchus bulbocolli* Linkins, l.c., p. 218.

Essex and Hunter ('26, p. 164) found these worms on two or three fish examined from the Mississippi.

NEMATODE WORMS

Camallanus aucylodirus Ward and Magath, Ward and Magath, '16, p. 58; also Ward and Whipple, '18, p. 529. *Spinitectus* sp.: Pratt ('23, pp. 61, 65) examined three Carp from Oneida Lake and found four nematodes of this genus.

LEECHES

Cole ('05, p. 579) found a Carp in Lake Erie, with a leech attached to it, and Pearse ('24, p. 181) notes *Placobdella montifera* Moore, attacking the species.

COPEPODS

Lernaea csocina (Burmeister), Wilson, '17, p. 195; *L. cyprinacca* Linnaeus, Wilson, '17, p. 196.

MOLLUSCA

Carp appear to be less susceptible than other fishes used in experiments to induce mussel infestations (Lefevre and Curtis, '12, p. 162). With glochidia of *Lampsilus*, artificial infestations seemed impossible with the Carp while successful with other species (l.c., p. 163). Success was, however, attained by using glochidia of *Anodonta*, of which 200-500 became established on the Carp fins in 30-40 minutes of exposure.

Economic Importance. The Carp affects our welfare in a number of ways, but principally as a food fish. Its introduction into American waters, as noted above, was due to its value for the table and the ease with which it may be raised; but the prejudice that developed against it in many localities has resulted in a lack of attention given to it, so that it has escaped into many of our natural waters in which it has become very abundant and now frequently is considered merely a nuisance.

The Carp is still of great commercial value on account of its utilization in certain localities, including New York City (Koelz, '26, p. 598). Dr. Hugh M. Smith wrote ('10, p. 1405): "It is regularly exposed for sale in every large city and innumerable small towns, it supports special fisheries in fifteen states, and it is regularly taken for market in thirty-five states. The sales at this time amount to fully 20,000,000 pounds annually, for which the fishermen receive \$500,000." On account of its being such an important market fish commercial Carp fisheries exist even in regions remote from New York City. For example, the Illinois River, according to Forbes and Richardson ('09, p. 106), produced six to eight million Carp a year, valued at \$200,000, and these fish were sent principally to New York City. Regarding the Illinois River Carp fisheries and others, Dr. Smith writes in the News Bulletin (Doc. 725, Bur. Fisheries) as follows: "The principal Carp fishery is in Illinois, where fishermen have for years been reaping a golden harvest, finding a ready sale in the West and also sending large consign-

ments to New York in special cars. The next important center is the western end of Lake Erie, in Ohio and Michigan, where large special ponds have been constructed and a peculiar form of cultivation has sprung up. Other important carp States are Colorado, Delaware, Iowa, Minnesota, Missouri, New Jersey, New York, Tennessee, Utah, and Wisconsin." At Monroe, Michigan, many Carp are taken and shipped to New York City. From here and from the Illinois River they are sent alive. They live well in transit provided the gills are kept moist by melting ice (Forbes and Richardson, '09, p. 106). Surber ('20, p. 41) says these fish are shipped alive from Minnesota to Chicago and New York. When sent to these distant parts they are fed grain for three or four weeks in advance (Leach, '19, p. 19). According to Canfield ('18, p. 6) the Carp, so shipped, are especially desired by the Jewish people who require fish in very fresh condition. The ease with which the Carp is put on the market in a perfectly fresh condition has made these distant fisheries possible. At present an important Carp fishery has developed at Oneida Lake and many Carp are being shipped from there to New York City.

The Carp fisheries of the Great Lakes, according to Koelz ('26), are principally at Green Bay, Wisconsin (p. 567), where 742,000 pounds were marketed in 1922; in Saginaw Bay of Lake Huron (p. 585), where 1,145,250 pounds were taken in 1917; and in Lake Erie (pp. 592 and 598), where 5,899,000 pounds were taken in 1922. In Oneida Lake, Carp have apparently only recently become of commercial importance. We obtained no evidence that they were very abundant in the lake while our field investigations were being carried on in 1915 and 1916, and they seemed to be conspicuous then only when concentrated at breeding grounds. No young were taken in our extensive seining operations, although Hankinson has caught young Carp by similar methods in similar situations about Cayuga Lake. Our extensive observations on fishes on the many shallows about Oneida Lake brought very little evidence of the presence of Carp in 1916. At present (1927) Carp are abundant in the lake. W. A. Dence has learned from Carp fishermen that 44 to 45 tons of large Carp, individuals averaging nearly eight pounds in weight, were taken from Oneida Lake in 1927.

In Europe the Carp has been a valuable species (Seeley, '86, p. 98), and Smith ('07, p. 107) mentions it as an item of commercial importance in a dozen countries. Nash ('08, p. 48) says it is valued in parts of Europe where good fish are scarce, but that there is no place for it in America where he considers its introduction a great mistake.

That more and better use of the Carp might be made in this country is evident, and this might be accomplished by enlightening people as to its possibilities as a food fish. Leach ('19, p. 17) advocates its propagation in waters unsuited for other more valuable fish, but also states that it should be used for food only during the cold months of the year, for its flesh is unpalatable when caught from warm waters. It should be prepared in approved ways (Taylor, '17, pp. 4-7; Leach, '19, p. 19). Smoked Carp is highly palatable and can be prepared in accordance with directions given by Leach (l.c., p. 19). Smiley ('83, p. 305) investigated the palatability of the Carp by sending questionnaires to persons who had used it for food. He gives the results of 600 replies. Smiley concludes that unfavorable

criticism of the fish for table use has been due to those who have eaten it too soon after the spawning season, and to improper preparation, including bad cooking. He advocates keeping the fish for a week in pure water, in tubs, changing it daily, as a part of the preparation for cooking. This removes the muddy taste (Cole, '05, p. 604). Evermann and Clark ('20, p. 341) consider the flesh of Carp sweet, better than that of the Large-mouth Black Bass, and recommend using fish weighing from five to eight pounds, which are better than the larger ones. Hankinson has seen Carp left on the shore of Cayuga Lake, by fishermen in winter. Here they would freeze and finally decay. Some of them when first dumped from nets on the shore were cooked by Hankinson and found to be good.

If people could be taught to prepare the Carp properly at the proper season, its use as food would very likely become much greater. It might even become so extensively sought that the present superabundance of this fish in our inland waters would be much reduced. The Carp, which has been called "the English Sparrow of our waters" (Cole, '05, p. 636), is clearly an undeveloped resource (l.c., p. 637) in this country. It is especially valuable because it makes aquatic plants indirectly available as food for man (Leach, '19, p. 18; Taylor, '17, p. 4).

Carp are known to interfere with other and more useful fish when abundantly associated with them, but there is considerable difference of opinion as to the destructiveness of the Carp in this way; and it is a proper subject for further investigations. Carp are destructive to shallow water vegetation and, in rooting about water plants, undoubtedly may interfere with the nesting of bass, sunfish and other fish that breed about these plants. Titcomb ('23, p. 20) found Carp destructive to vegetation in bass ponds. He placed several in a part of a pond where there were growing *Ceratophyllum*, *Philotria*, *Potamogeton*, *Vallisneria*, and *Nymphaea*. When the water was drawn in the fall, this part of the pond, which had been partitioned off for the experiment, was found to be absolutely destitute of any kind of vegetation; and the following season, when the Carp were excluded, the plants became as abundant as formerly. Embury ('22, p. 16) considers it destructive to spawning grounds of other and better fish, through its uprooting of aquatic plants. Cole ('05, p. 593) discusses its destructiveness to plant life by making the water roily through its rooting activities, and it seems to him probable that plant growth may be greatly reduced by this roiliness.

In destroying vegetation, Carp not only interfere with other fish but do damage in other ways. They have been accused of reducing feeding areas for wild fowl and hence of interfering with the interests of the sportsmen. Cole ('05, p. 587) who has carefully investigated this charge gives instances where the introduction of Carp in certain waters has been followed by a decreased production of wild celery and other plants serving as duck food; and this decrease was accompanied by a growing scarcity of ducks. He concludes (l.c., p. 592) therefore that the Carp are probably responsible for the great reduction noted of wild celery and wild rice, and this in turn has deprived the ducks, especially the Canvasback and the Redhead, of an important food supply, which has influenced their abundance in certain localities. But he does not consider the Carp the cause of a general decrease of these game birds. He also notes (l.c., p. 635) that "In most cases the reported damage has been either greatly exaggerated or is entirely unfounded."

In destroying vegetation Carp may be beneficial and are sometimes introduced into trout ponds to eat up algae (Cole, '05, p. 609). Dyche ('14, p. 128) reports finding 1000-5000 weed seeds in one Carp stomach; and there may be circumstances under which this fish, like our seed-eating birds, may be beneficial through destroying weeds, for it is well known that running waters act as distributors of plants through carrying seeds that later become stranded and germinate.

The importance of Carp as food for the more desirable fish species has apparently not been fully appreciated. The U. S. Bureau of Fisheries has raised Carp for feeding bass (Cole, '05, p. 609), and Dr. Hugh M. Smith in an unpublished statement sent to us says: "It is probable that the commercial value of carp is insignificant compared with its importance as a food for other fishes. It is extensively eaten by many of our most highly esteemed food fishes and is the chief pabulum of some of them in some places. In a number of the best Black Bass streams, like the Potomac and the Illinois, the Carp is very abundant and is a favorite food of the young and adult bass, while in California the introduced striped bass has from the outset subsisted largely on Carp and may owe its remarkable increase to the presence of this food."

The destructiveness of Carp to the spawn of other fish has been assumed to be extensive, but Cole ('05, p. 595) shows that inferences have been made from too few data. More information from direct observations and stomach examinations is needed. Bass and sunfish may be interfered with to a certain extent, but they probably are able to drive Carp away from their eggs (l.c., p. 600), and the breeding periods and habitats of most of our other fish of commercial value, like Pike Perch, Perch, Pickerel (*Esox*), trout and whitefish, are such as to make it unlikely that Carp destroy many of their eggs (l.c., p. 595). According to Embury ('22, p. 16), Carp destroy spawning grounds and cover eggs with mud by uprooting vegetation and roiling the shallow water; but Forbes and Richardson ('09, p. 108) consider the statistics showing the increase of food fishes associated with Carp in the Illinois River, to mean that Carp do not interfere with the breeding of these species in any important way. Furthermore, Dyche ('14, p. 126), in opening more than a thousand Carp stomachs, found no eggs of other fishes in the food masses, although there were in a few instances small numbers of their own eggs. Evermann and Clark ('20, p. 342) also note the scarcity of fish eggs in Carp stomachs.

Carp very probably affect other fishes in their habitat by competing with them for food. The food of the young Carp is similar to that of the young of our important food fishes, being chiefly small crustaceans and aquatic insects. Greeley ('27, p. 56) considers that this competition gives "The most tenable argument against Carp in relation to other fishes." Embury ('22, p. 16) likewise notes that the feeding habits of Carp are such that its presence in our lakes is at the expense of more highly esteemed fishes, but does not give the evidence for the opinion.

By keeping water roily Carp destroy the beauty of small lakes (Cole, '05, p. 636), and when in reservoirs—which are sources of water supply for communities—they may become a great nuisance (l.c., p. 635).

Hunt ('12, pp. 190-191) gives instances where Carp appear to have reduced the number of mussels, since the mussels were abundant in certain regions prior to the advent of the Carp, and they were found in quantities in the enterons of the fish.

Carp are apparently important in some localities as eradicators of fluke disease in sheep. Stiles ('02, p. 220) notes the considerable disappearance of this disease in sheep in the Columbia River bottoms after the introduction of the Carp. Cole ('05, p. 609) quotes Dr. B. W. Evermann as saying that Carp eat the snails (*Limnaca*) that harbor stages in the life history of the flukes, referring to the habit of the fish of rooting about in the grass areas of bottom land during annual overflows.

Carp may also be of importance as mosquito destroyers, for Gill ('05, p. 206) states that the larvae of mosquitoes are especially acceptable to the young. Cole ('05, p. 608) also thinks it quite probable that Carp may be important mosquito destroyers notwithstanding the fact that the pest has not actually been found abundantly in the intestinal contents of this fish. This fact he considers may have been due merely to the small size of the larvae, for since Carp are known to feed extensively at times on larvae of other insects, he is led to suspect that mosquito larvae would be taken as well.

Carp have also been used as fertilizer. Forbes and Richardson ('09, p. 108) state that owing to the low price which the fish brings in the spring, often not more than a third of a cent a pound, many are used in the Great Lakes region for this purpose. Cobb ('04, p. 229), in writing of Cayuga Lake, mentions the waste of Carp, saying that many thousands of pounds of Carp (and Dogfish) are thrown upon the shores to rot or to be used as fertilizer. Hankinson also recalls the considerable waste of Carp about Cayuga Lake where, about the year 1900, he has seen hundreds of them left on the shore by net fishermen. One winter he secured some of these discarded fish, frozen, but in fresh condition, cooked them and found them very palatable.

On the whole the Carp would seem to be a highly valuable fish in this country. It probably needs only a more extensive, intelligent, and more economical utilization. Accordingly, where superabundant and interfering with better native fish, its capture for food purposes should be encouraged. Cole ('05, p. 636), in considering the idea of placing bounties on the fish, says: "The best bounty that can be offered is an increasing market—a growing demand that will make fishing for Carp a profitable business." It seems probable that in the future Carp will become more and more important, following the growing scarcity and increased prices of many of our native food fish. Prejudices, however, based on wrong information concerning the fish should be removed, and instructions as to proper ways of preparing it for the table should be more generally disseminated.

By way of summary of the economic importance of the Carp in this country, the following quotation from Smith ('10, p. 1405) is given: "Of all the exotic fishes, none is so well known, so widely distributed, so abundant, and so valuable as the carp, which was introduced from Germany upward of thirty years ago. This fish has excited a great deal of criticism, mostly unfriendly, and it is today regarded with disfavor by many people, chiefly anglers, because of real or supposed

habits that are reprehensible. As a commercial proposition, the bringing of the carp to America has been of immense benefit, for today it is one of the common food fishes of the country."

Culture of the Carp. The Carp has been cultivated extensively in ponds in this country, and its presence in wild waters has been due, as above noted, to its escape from these ponds through carelessness or neglect. Carp may be raised with considerable profit in ponds, under some circumstances, and Leach ('19, pp. 3-12) gives ample directions with diagrams for the construction and care of such ponds. Cole ('05, pp. 622-630) has also many suggestions for pond culture of Carp; and likewise Smiley ('83, pp. 244-249), but details of pond construction and care need not be given here, especially since Oneida Lake and the abundance of other suitable Carp waters in New York State do not present important pond culture problems. However, we do need to give more attention to the fish where they now occur, and some knowledge of Carp culture in ponds will be of use to us, especially in connection with small water areas. At present, Carp are said to be abundant in discarded portions of old canals, and here they might well be cared for. W. A. Dence saw a good many Carp on June 20, 1927, and also on later occasions, in parts of an old Erie Canal feeder near Fayetteville, N. Y., where there was a very profuse growth of vegetation on a muddy bottom. It may be advisable under some circumstances to feed the fish. Cole ('05, p. 630) tells of this being successfully done by using young corn plants one to two feet high. Leach ('19, p. 16) however, recommends cooked vegetables, such as cabbage, potatoes, corn, or turnips, and says they will thrive on a low grade of flour, bran, or shorts made into a bread thoroughly cooked as if for table use. If Carp are to be raised or encouraged in any waters, these should have abundant vegetation if possible. Smiley ('83, p. 244) names the following plants as best for Carp waters: crow-foots, cowslips, water milfoil (*Myriophyllum*), bladderwort (*Utricularia*), hornwort (*Ceratophyllum*), cress, water rice (*Zizania*), water-mace, water oats, Indian rice and water lilies.

As to the importance of Carp as pond fish, Dr. Smith ('10, p. 1405) writes: "It is not as a great market fish, however, that the carp is destined to attain its highest importance among us, but as a fish for private culture and home consumption. The number of farmers and small landowners who are alive to the benefits of private fish ponds is increasing at a very rapid rate, and hundreds of thousands of such in all parts of the country, but particularly in the great central region, will find in the carp a fish well adapted to their needs and conditions."

Angling and Methods of Capture. Many methods are employed in Carp capture. Commercial fish are caught with nets such as fyke nets, pound nets, drag seines, trammel nets, and gill nets (Canfield, '18, p. 1). Farmers often spear Carp when they are running into the shallows for breeding; pitchforks are commonly used. J. D. Black informed us of their capture in this way about the lowlands along Chittenango Creek; and W. A. Dence has seen many taken in this way in tributary streams of Oneida River at Brewerton. Durand ('11, p. 30) lists the methods used in capturing commercial Carp, with the pounds of fish taken by each method. The figures are as follows:

Fyke and hoop nets.....	10,067,000 lbs.
Lines	1,062,000 lbs.
Trammel nets.....	5,154,000 lbs.
Pound nets, trap nets, weirs....	1,224,000 lbs.
Gill nets.....	894,000 lbs.
Other nets.....	115,000 lbs.
Pots and traps.....	23,000 lbs.
Spears	58,000 lbs.
Other apparatus.....	2,000 lbs.

Line fishing for Carp is a common sport and frequently we see, commonly the poorer people, patiently awaiting a bite, though a fish is but rarely taken. At times, however, various baits are successfully used in Carp fishing. Dough balls are very generally employed for this purpose but other baits are worms and insect larvae, such as those of wasp larvae. Grains of wheat or barley and pieces of beef or fish are sometimes used (Bean, '02, p. 291). Leach ('19, p. 18) says that potatoes half cooked are the best bait for large fish; and he recommends a dough made of plain or sweet paste, peas, or boiled potatoes. Canfield ('18, p. 5) considers composite pastes the best Carp baits and gives directions as follows: "A tough paste may be made of moistened bean, wheat, or other flour, thoroughly mixed with a little sugar, or preferably honey. To give the paste a greater tenacity, cotton batting or wool should be stirred in." Henshall ('19, p. 239) says that one of the best baits is a red earthworm. Dence has caught specimens about the size of sunfish, near the mouth of Young's Creek, Oneida River, after a heavy rain, with earthworms as bait.

"Ground baiting" is often practiced in Carp fishing, either with line or net. This is often done by dumping in a bushel or two of corn or oats, or both (Canfield, '18, p. 5), at feeding places like deep inlets or bayous of rivers. Goode ('03, p. 415) says that anglers in Germany bait the ground with a thousand or more earthworms twenty-four hours before fishing, and while fishing throw more victims in the water. Canfield (p. 4) notes the "advanced baiting" by old anglers, which consists in placing in the water, some six to eight feet from shore, pieces of boiled potatoes, or other cooked vegetable material such as kitchen waste; this baiting is done for several successive days before fishing.

The Carp is not ordinarily considered a game fish, but Henshall ('19, p. 240) says: "When once hooked, the fish is not to be lightly esteemed. The angler will have all he can attend to with a light rod in a weedy pond, or even in clear water if the fish is of large size."

Carp are caught with simple equipment, and ordinarily a long cane pole is used. Hunt ('12, p. 189), however, recommends using a reel with 75-100 yards of strong line and anchoring the rod on shore by driving a stick into the ground between the line and the rod, just before the reel, for the Carp gives no warning and might take rod and all into the water. Henshall ('19, p. 241) also advises fixing the rod in the bank and lying down beside it or placing one's self behind a bush or screen till the movement of the float announces the taking of the bait by the fish, because the Carp are very wary and the angler or his shadow must be out of their view (Canfield '18, p. 4; Henshall, '19, p. 243). Cole ('05, p. 553)

found Carp to be very shy when he was making his observations on them in Lake Erie; and he found that when he was perfectly still upon his observation platform, the fish would not approach nearer than a certain distance to him. He accords the fish a keen sense of sight; but the capacity to hear sounds produced out of water, such as the sound of anglers talking, the Carp does not seem to possess (p. 555).

Carp are successfully taken by set line or trot line. Canfield ('18, p. 4) describes the method. The main or leader line varies in length according to the size of the body of water, and hooks on lines 4-6 inches long are placed at intervals of three to five feet. The trot line is anchored in the position desired, and is provided with floats when necessary. Dough balls, pork rinds, crawfishes, grasshoppers, earthworms and other baits are used. It is very likely that this method of fishing could be employed with success in Oneida Lake.

References. Adams and Hankinson, '16; Allen, '13; Annin, '98; Baker, '16; Bartlett, '06, '10, '18; Bean, '92, '02, '03, '07; Canfield, '18; Cobb, '04; Cole, '05; Dimmock, '87; Durand, '11; Dyche, '14; Ellis, '14; Embury, '15, '22; Essex and Hunter, '26; Evermann and Clark, '20; Forbes, '88b; Forbes and Richardson, '09, '19; Garman, '91; Gill, '05; Goode, '84, '03; Gill, '05; Greeley, '27; Gurley, '94; Hay, '94; Henshall, '19; Hessel, '78; Hunt, '12; Jordan, '05; Koelz, '26; Leach, '19; Lefevre and Curtis, '12; Meek, '16; Nash, '08; Nichols, '13; Nichols and Heilner, '20; Pearse, '18, '24; Pratt, '23; Reed and Wright, '09; Seeley, '86; Smiley, '81, '83, '83a, '84; Smith, '96, '07; Stiles, '02; Stiles and Hassall, '08; Taylor, '17; Titcomb, '23; Townsend, '09; Tracy, '10; VanCleave, '19; Ward and Magath, '16; Ward and Whipple, '18; Wetmore, '24; Wilson, '17.

Rhinichthys atronasmus (Mitchill). BLACK-NOSED DACE. This is a characteristic fish of small rapid brooks and none were taken in the lake proper, but specimens were taken at the mouths of tributary streams. The fish is used as bait, and serves as food for trout in streams.

Breeding Habits. Very little is recorded about the breeding habits of this common fish. Wright and Allen ('14, p. 5) give the breeding season at Ithaca, N. Y., as May 24th to June. Here it is said to breed in "shallow water, gravelly riffles or on vegetation." Forbes and Richardson ('09, p. 163) report breeding males taken during June in Illinois, and mention that "spring males have the front of the head and the occipital region finely tuberculate." Kendall and Goldsborough ('08, p. 34) found it in northern New Hampshire, and report that "the spawning time is in the spring and early summer, when the males assume a more brilliant coloration, more or less red being evident, and often the intensely black stripe seems to be margined with reddish golden or bronze." Holder ('83, pp. 101-102), in describing the breeding habits, tells of the fish carrying pebbles to form a pile in which the eggs are laid. Since this is not in accord with unpublished observations of Reighard and Hubbs and others, it is likely that some other species has been confused with it.

In the males, according to Fowler ('12, p. 473), the front and predorsal regions are minutely tuberculate during the spring and early summer.

Habitat. All our collections came from the small rapid brooks between Constantia and North Bay, along the north shore of Oneida Lake. Shelford

('13, p. 22) rates this species as second from the source in intermittent streams, surpassed only by the Chub, *Scmotilus atromaculatus*. He also states that the Dace "go against the current, but avoid the places where it is most violent . . . and can withstand the stagnant conditions of the summer pools." Fowler ('98, p. 152) says: "They are seldom found in the creeks or wider streams in such abundance as in the small brooks of clear water, particularly if rapid. They also like the quiet little pools or deeper places. Here they may often be seen swimming persistently against the current, sometimes gaining a few inches or again slipping back perhaps further, and then darting suddenly away when disturbed, only to be seen, however, back again repeating the same performance over and over." Greeley ('27, p. 60) says of this species in the Genesee system that it is abundant in small streams, in both warm and cold waters, that it avoids large streams and is nearly always present in trout streams.

Food. Kendall and Goldsborough ('08, p. 34) state that this dace feeds upon "small aquatic animals and insects. Young individuals from 1.20 to 1.66 inches long were found to be feeding upon diatoms, Entomostraca, small aquatic worms, and fragments of insects."

Breder and Crawford ('22, pp. 304, 305) studied the food of 191 Black-nosed Dace taken at different times during the year. Insect material composed 57% of the food; this included larvae of various aquatic insects, caterpillars, and some adult Coleoptera, Diptera, and Hymenoptera. Filamentous algae composed 24% of the food; the rest of it was largely undeterminable. Greeley ('27, p. 60) reports on the food of six specimens collected in the Genesee River system of New York State in summer. Midge larvae constituted 70.8% of the food; May-fly nymphs, 16.6%. The rest of the food consisted of crustaceans, water mites, diatoms and other vegetable material.

Distribution Records. None of our specimens came from the lake proper; all came from small tributary streams, but in situations close to the lake. No. 142 came from Frederick Creek, between the railway track and the State hatchery; one adult (No. 447), from a small stream entering the west side of east Potter Bay; 2 specimens about 2¼ inches long (No. 553), from a small swift, rocky stream entering the lake at West Vienna; 10 specimens, the smallest two about 5¾ inches long (No. 458), from a small stream entering the west side of east Potter Bay; 13 specimens, averaging about 1½ inches (No. 593), from a small rapid stream at North Bay; 10 specimens (No. 594), including a single fish about ½-inch long from a pool in a small stream 1½ miles east of West Vienna. The remains of two were found in the stomach of a Chain Pickerel.

Enemies and Disease. In trout streams this dace is probably preyed upon by the trout. Kendall and Goldsborough ('08, p. 32) remark that in northern New Hampshire this fish is also called "potbelly" and "pottle-belly," because it is frequently distended with tapeworms; and Jordan ('05, Vol. 1, p. 342, Fig. 227) figures a specimen of *R. atronasus* with numerous skin parasites. Gentry ('77, Vol. 2, p. 110) records the Black-nosed Dace as food of the Kingfisher, *Ceryle alcyon*.

Economic Relations. The economic importance of this fish consists largely of its value as food for trout, and its utility as bait. It also probably does good service in devouring mosquitoes and blackfly larvae that thrive along trout streams.

Bean ('08, p. 156) states that in the aquarium it is "more hardy than any other minnow," and Mather ('86, p. 32) tells us that "it is a lively fish, usually in swift water, but thrives in the aquarium." Running water would probably need to be provided for the aquarium. Abbott ('90, p. 419) says they do not live in quiet water, which has also been Hankinson's experience with adults of this species. The young, however, an inch or so long, often school in large numbers in small quiet marginal bays and bayous of streams.

Angling Notes. The bait qualities are well expressed by Kendall and Goldsborough ('08, p. 34): "The larger individuals of this little species are hardy and make an attractive bait for salmon and trout. They may be caught with a small hook and worm bait, but this is a slow method. The most satisfactory method is by minnow traps; a small seine or dip-net is sometimes effective in brooks that are clear enough, where the ingenuity of the fisherman may indicate ways and means of driving the fish into the nets."

References. Abbott, '90; Bean, '08; Breder and Crawford, '22; Forbes and Richardson, '09; Fowler, '06, '12; Gentry, '77; Gregg, '79; Greeley, '27; Holder, '83; Jordan, '05; Kendall and Goldsborough, '08; Mather, '86; Reighard, '03, '03a; Shelford, '13; Wright and Allen, '14.

Rhinichthys cataractae (Cuvier and Valenciennes). LONG-NOSED DACE. Found but once in Oneida Lake, but abundant in the small tributary streams on the north shore between Constantia and North Bay. It is a characteristic species of swift waters, as is indicated by its scientific name.

Breeding Habits and Life History. Very little indeed is known about the habits and life history of this very interesting species. Its western relative, the variety *dulcis* Girard, is reported by Ellis ('14, p. 67) to spawn early in the spring, in Colorado. When the males are mature, says Fowler ('12, p. 473), the "Snout, top of head, entire back, and rudimentary dorsal rays are minutely tuberculate in the spring. No tuberculate females are known." Our largest specimen measures 4 inches long (No. 458).

Habitat. This fish thrives in swift waters. A single specimen (No. 500) 3½ inches long, was taken in Oneida Lake, all the others from brooks, in the most rapid water (Fig. 220). In the small pools at the foot of the swiftest water the seines caught them in large numbers. That the fish occasionally lives on exposed shores of lakes, is in harmony with its presence in the beach-pools at Georgian Bay, Lake Huron, where, as Bensley ('15, p. 20) says, "It is practically the only fish inhabiting those pools, though those open to the outside water sometimes contain other species. The fish lurks under stones and is only taken by strategy." In the brooks we walked upstream in the rapid water, seined against the current and in this way secured them in abundance. This is one of the most characteristic fishes in the small headwaters especially of streams of the mountain-brook type. Fowler ('06, p. 150) says, "It is found in clear, rushing torrents, most always in the rapids or rock pools"; McAtee and Weed ('15, p. 9) say, "*Rhinichthys cataractae* were usually in swirling pools just beneath miniature cataracts"; and Abbott ('90, p. 420) states that this species is more dependent than is *atronsus* "upon clear running water, and dies immediately if placed in still water, as in an aquarium. Even water kept cold with ice does not suffice; it must be both cool and rapidly flowing,"

and he further adds, "I have usually found them beneath flat stones, or hidden by the overhanging banks of the brook."

Food. The food of the variety *dulcis* in Colorado is thus given by Ellis ('14, p. 67): "The stomach contents of 20 specimens from Boulder Creek near Boulder showed that the algae and brown diatomaceous slime so generally eaten by herbivorous Cyprinids are important elements in the food of this minnow, forming about two-thirds of the material. Small crustaceans, insect larvae, small snails and water-logged material comprised the remaining third. It is known that the Dulcis Minnow also eats the spawn of the trout. On the other hand, the Dulcis Minnows are eaten by the trout, making the presence of these minnows in the mountain streams of value." Hankinson ('16, p. 136) examined the stomach contents of specimens in northern Michigan and found that the dace "were eating black-fly larvae, which made up all of the material in the intestines of four of the Dace opened." This observation has an important bearing on the economic value of the fish. Clemens ('24, p. 113) found in seven specimens food composed of *Chironomidæ* larvae to the extent of 77%; *Epheméridæ*, 7%; *Sida*, 11%; and the rest, other crustaceans, insect material, algae (*Ulothrix*) and diatoms and in one fish taken July 30, 1923, there were a hundred fish eggs, making up the entire stomach contents, except for an insect fragment. Greeley ('27, p. 60) analyzed the food of three fish about $\frac{3}{4}$ inch long, taken July 2, 1926, in the Genesee River, New York. They had eaten the following: midge larvae, adult midges, May-fly nymphs, caddis-fly larvae, pollution worms (*Tubificidæ*), filamentous algae, including *Ulothrix* and *Spirogyra*, and diatoms.

Distribution Records. One Oneida Lake specimen, No. 500, was taken in the bay just west of Lewis Point, in shallow water at the edge of vegetation, on sand bottom; Nos. 447 and 458, from a small stream on the west side of East Potter Bay; No. 460, from Black Creek at Cleveland; No. 553, from the small brook at West Vienna, a large series, No. 593, from the small, rapid brook at North Bay; and No. 594, from a small boulder studded pool in a stream $1\frac{1}{2}$ miles east of West Vienna. All these streams are small, usually not more than 20 feet wide.

Enemies and Disease. Beyond the fact that trout prey upon this dace no mention has been found of predators or parasites. In our series there are several diseased specimens. One (No. 553) has a nodular swelling at the base of the dorsal fin, and another a large wart-like nodule, nearly a quarter of an inch in diameter, anterior to the right eye; in another collection (No. 593) there is one with a large blackened nodule on the left of the dorsal fin, and another with numerous blackened areas on the skin, some of them vertically elongated. Three fish (No. 460) show scattered pigmented skin patches or small elevations. These are possibly due to sporozoans. Hankinson's observation that *Simulium* larvae are eaten in numbers by this dace shows how much diseases may be easily transmitted, because these larvae are often heavily infested with sporozoans, as Strickland ('13) has shown. *Simulium*, the Long-nosed Dace, and the trout may possibly form a cycle of transmission for disease.

Economic Relations. Our present knowledge indicates that the main economic value of this fish is its use as food for trout and as bait. Bean ('03, p. 154) thinks that "As a bait for the Black Bass it is scarcely surpassed." These dace can be

procured easily by seining against the current while at the same time poking among the stones and gravel. The value of this fish in reducing the numbers of black flies (*Simulium*) particularly along trout streams, is worthy of a special investigation. There is also the possibility that this dace may transmit sporozoan diseases to trout, another subject worthy of special study. Just as certain other fish are of value in mosquito control so these may be of value in the control of the black fly.

References. Abbott, '90; Bean, '03; Bensley, '15; Clemens, '24; Ellis, '14; Fowler, '06, '12; Greeley, '27; Hankinson, '16; McAtee and Weed, '15; Strickland, '13.

Leucosomus corporalis Mitchill. FALLFISH, SILVER CHUB, Chub. This is the largest species of minnow native to Oneida Lake. The species appears to be one of rapid streams, although it also thrives in the lake.

Breeding Habits and Life History. The Fallfish (Plate 2) breeds in the quiet waters of streams and in the shallow margins of ponds and lakes. The male, according to Atkins (Kendall and Goldsborough, '08, p. 27), excavates a nest by carrying stones in his mouth and dropping them to form a low ridge of gravel a foot wide and three feet long. He guards the nest and drives away other fish that may be intruders. A female which came swiftly along and stopped right over the gravel pile was seen "Struggling in an erect position; the male was close to her, but nothing more could be made out. Then the female disappeared." Only this one male remained over the nest. A number of females, as they were supposed to be, came to the nest several times. "In general there was a sudden gathering of a number of fish from the immediate neighborhood, comprising all the chubs within 5 or 6 feet or more, and a simultaneous rush for the nest, where only a confused mass of struggling fish could be distinguished; some of them turned over so that the gleam of the white of their bellies were seen. The old male was always there." These observations were made in Maine on May 8 and 9, 1878, and are seemingly the most definite that have been published.

The mature fish reaches a length of 18 inches, but varies much in size, for in "small brooks it reaches maturity when only a few inches long" (Kendall and Goldsborough, '08, p. 26). Fowler ('12, pp. 472-473) states that, "The fully adult male is with brilliant rosy sides and mostly rosy fins. Though reaching a length of nearly two feet, examples three inches long have been taken with fully developed eggs. The only tuberculated examples were all over a foot in length and had their muzzles densely covered with small tubercles. No nests were ever found made by the small fish of three or four inches in length. The nests discovered were attended only by large fish."

Charles G. Atkins ('05, p. 189), writing of the culture of the Fallfish, says: "Chubs spawn in the month of May in this latitude (Maine) and I presume it would be very early in April in Maryland. They build great heaps of gravel in streams, appearing to avoid the most rapid water. They spawn over the heaps, many individuals using the same nest and gathering in crowds for the act. The males build the nests, bringing the pebbles together in their mouths. I took a few eggs on May 7th and found them to be non-adhesive. A female of moderate size

gave about 2000. Fecundated by the "dry" method, that is, without the addition of water until the fecundation was effected, and placed for incubation in a floating wire box, they hatched very well in from seven to nine days, the temperature of the water being from $54\frac{1}{2}^{\circ}$ F. to $63\frac{1}{2}^{\circ}$ F., averaging under 60° F."

The "Awadosi" referred to by Robert Bell ('97) were undoubtedly of this species. Fish were seen depositing stones from an ounce to a pound in weight, in heaps containing from a "wheel-barrow load to four or five tons" each. The working fish were from a pound to three or four pounds in weight. They worked together and the size of the nest depended upon the number of workers. Stones were brought in their mouths from far and near.

Habitat. This is mainly a stream fish but is also fairly abundant in standing water, particularly near the mouths of streams in lakes. Fowler ('06, pp. 130-131) says: "It is often found about rapids and falls, from which it has earned the name of fall fish. The large ones occur in rivers or other large bodies of fresh water. Those most likely to be met with are in the smaller streams of clear water, not very deep, and with good protection of vegetation along the banks. A stream which may be easily waded, and with here and there a deep pool into which the fish may dart when disturbed, are the most favored." "It prefers clear swift streams, rocky pools below cataracts, or clear cool lakes" (Evermann, '01, p. 316).

Food. Baker ('16, p. 171) examined two specimens (No. 76) from Frederick Creek at Constantia, and found one with the stomach and intestines empty, the other with two crawfishes, *Cambarus bartoni robustus*, and the remains of a small frog. Kendall and Goldsborough ('08, p. 26) state that the Fallfish eat almost all kinds of food, and frequent the mouths of sewers and drains. Fowler ('06, p. 132) says that the food consists of insects, "frequently apple bugs (*Gyrinidac*)." Warren ('97, p. 27) saw a young ground sparrow devoured by a 16-inch Fallfish. Evermann and Kendall ('96, p. 604) report ten of these fish about 4 inches long from the stomach of a Burbot, *Lota maculosa*. Breder and Crawford ('22, p. 295) give the results of examinations of 242 fish: 87% of the food was insects, which were larvae of some aquatic and some terrestrial forms, besides beetles, flies and Hymenoptera. The 13% non-insect food was composed of plants, such as diatoms and filamentous algae, some other invertebrates and one fish (*Bolcosoma*). From the character of the food found (see table of food, p. 296) and from aquarium observations, the authors infer that the Fallfish gets most of its food just above the bottom, and just below the water surface. The food was found to be similar in fish of all sizes.

Distribution Records. Our collections consist mostly of small specimens, only a few larger ones having been caught: No. 76, a single large fish from a pond-like bay just west of the mouth of Scriba Creek, Constantia; No. 77, on a sandy beach of Bullhead Bay, a single small fish about $1\frac{3}{4}$ inches long; No. 86, several small fish about 2 inches long, on sand with scattered stones, in open spaces between bulrushes, Paddygut Point; No. 120, a single small specimen from Big Bay Shoal, near Belknaps Landing; No. 345, a single specimen almost 3 inches long, at Lower South Bay; No. 422, 4 small specimens from Dakins Bay, near the school-house, near patches of *Typha*; No. 463, 3 small specimens, from the west side of East Potter Bay, among aquatic plants; No. 470, a single small specimen, among



Plate 2. FALLFISH, *Leuciscus corporalis* Mitchell.

vegetation in a bay east of Cleveland; No. 471, several large specimens, in water 3 to 4 feet deep, beyond the plant zone, in the bay east of Cleveland; No. 501, numerous specimens between 2 and 3 inches long, over bottom with scattered vegetation, in the bay west of Lewis Point; No. 502, 2 specimens nearly 4 inches long, from near shore, over firm sand bottom, in bay west of Lewis Point; No. 552, 3 specimens, similar in size and smaller than the preceding, over sand and cobble bottom with little vegetation, at West Vienna; No. 577, several young, about an inch long, along a swampy shore of Three Mile Bay; No. 585, many young, about an inch long, along shore, west of the pier at Lower South Bay. All of the above were from shallow shore waters, except No. 471 which was taken in 3 to 5 feet of water. The following specimens are from tributary streams: No. 88, 2 young, about 2 inches long, from a shore collection at the edge of vegetation, in Chittenango Creek, about $\frac{1}{8}$ of a mile above the cut-off island; No. 142, a single specimen, about 4 inches long, from Frederick Creek, between the railway track and the hatchery, Constantia; No. 525, numerous specimens, about 2 inches long, from a small stream flowing into Dakin Bay; No. 593, 2 diseased specimens and 3 smaller ones, from a small rapid stream flowing into North Bay; No. 594, numerous young, about an inch long, from a pool in a small stream about $1\frac{1}{2}$ miles east of West Vienna. A large market specimen (No. 360) was secured at Brewerton, which is 14 inches long.

Enemies and Disease. Living in small, clear streams easily accessible to predatory aquatic mammals and birds, this fish is probably devoured by many creatures, but little is definitely known on this subject. Loons (*Gavia immer*), according to Warren ('97, p. 298) and Fowler ('13, p. 8), feed on the Fallfish. Warren (p. 310) also took Fallfish from the stomach of the Green Heron (*Butorides virescens virescens*). The trematode *Diplastomum parvulum* Stafford (Stiles and Hassall, '08, p. 157) is recorded from the Fallfish, and Ward ('12, p. 226) extracted trematodes, cestodes, nematodes and *Acanthocephala* from the same species. A cestode, *Ligula monogramma* Creplin, is recorded from the Fallfish by Leidy (cf. '04, p. 77) under the name of *Leuciscus pulchellus*. Among our own specimens only a few lots were observed to be diseased. No. 491b contains four specimens slightly infested with skin parasites, apparently nematodes; and No. 593b includes two specimens which have a translucent belt about a half inch wide back of the dorsal fin, evidently a mark of disease.

Economics and Angling. In Oneida Lake this species is too rare to be of economic importance, although in the larger tributary creeks the young individuals are valued highly for bait. Henshall ('17, p. 268) refers to the Common Chub, *Semotilus bullaris*, and the Horned Chub, *Nocomis*, as bait for black bass, saying: "The Chubs are good bait on bright days with clear and still water; they have rather tough mouths and endure the hook well, and are rather more lively than shiners, and on these accounts are preferred by many anglers."

References. Atkins, '05; Baker, '16; Bell, '97; Breder and Crawford, '22; Evermann, '01; Fowler, 'c6, '12, '13; Forbes and Richardson, '09; Henshall, '17; Kendall, '96; Kendall and Goldsborough, '08; Leidy, '04; Stiles and Hassall, '08; Ward, '12, Warren, '97.

Semotilus atromaculatus (Mitchill). HORNE DACE, BROOK CHUB, MUD CHUB, CREEK CHUB. The Horned Dace is mainly a stream fish and only a few specimens were taken in Oneida Lake. Those taken were small and the species probably is not abundant enough there to be of importance as bait.

Breeding. The interesting breeding habits of the dace have been carefully studied by Reighard ('10, pp. 1125-1135), but only a part of his results have been published. He states that the breeding occurs usually in small streams (p. 1134), "on bottom of coarse gravel, and usually at the heads of rapids." The male builds the nest by carrying stones for it in his mouth or pushing them along with his head, and then guards it from other males. While the nest is being built females enter it and a complicated spawning behavior takes place in which a relatively small number of eggs are laid, after which the female leaves the nest, and may return again or visit other nests until all her eggs are deposited. The pearl organs on the head of the male are used in combats. Wright and Allen ('13, p. 4) give the breeding season for Ithaca, N. Y., as from April 20 to July, and describes the breeding place as "smaller pebble heaps in quiet water of riffles and gravel bars in lakes." Kendall and Goldsborough ('08, p. 29) say: "The mud chub spawns in early summer, at which time the body of the male becomes orange color, and there are horny excrescences on the snout and top of the head." Hankinson ('08, p. 205) found nests and spawning fish on June 1, in southern Michigan and in Central Illinois, and figured (Hankinson, '10, p. 4) the nesting habitat. He has also briefly described the nest ('09, pp. 239-240). He has hatched the eggs in aquaria during April. Evermann ('01, p. 317) states that "During the spring it will be found upon the riffles and coarse gravel bars, where it comes to spawn and where it constructs elaborate and conspicuous nests. When the spawning season is over and the water has become warmer, the Creek Chub will more often be found in the deeper and more quiet pools, where it feeds upon angle-worms, insect larvae, and such other small animals as come in its way." Leonard ('27, p. 39) studied the growth of the Horned Dace. He found that the most rapid growth is during the first year, the rate decreasing considerably after that.

Habitat. Kendall and Goldsborough ('08, p. 28) describe the habitat of this species by saying it differs in some respects from that of the Common Chub (*Semotilus bullaris*), more often being found in brooks and streams, especially in quiet "weedy" places and muddy ponds, yet both not uncommonly occur together. Hankinson ('13, p. 106) states that it prefers small creeks, and Shelford ('13, p. 90) has called attention to this as one of the pioneer fishes in small streams, and has shown (p. 106) how drouth drives this fish down stream. Evermann ('01, p. 317) says: "In the small streams, where it most abounds, it is often the largest and most voracious inhabitant. It rarely occurs in lakes or ponds, but may be found in the larger creeks and rivers, though it prefers the smaller creeks and brooks." Ellis ('14, p. 126) records it from water with a temperature of 84° F.

Food. Baker ('16, pp. 171, 205) has summarized our knowledge of the food of the Horned Dace, which consists of algae and other vegetable matter, insects, crawfishes and small fishes. Evermann ('01, p. 318) calls attention to the relation of the Chub to the trout, and remarks that Chubs are very fond of the eggs and fry of the Brook Trout. Hankinson ('10, p. 30) found the food to consist of

insects, including Chironomus larvae, and ('16, p. 23) a variety of small animals. Leonard ('27, p. 39) examined the food in the digestive tract of 53 individuals. A great variety of insect material was found together with remains of some crawfish and other invertebrate parts. Greeley ('27, p. 58) found the food of seven of these chubs taken from the Genesee River system of New York to be as follows: aquatic insects, 31.4%; terrestrial insects, 28.4%; crawfish (in one fish only), 14.3%; snails, 7.3%; grass seeds (in one fish) 2.8%; vegetable débris (in two fish), 15.7%.

Chubs feed extensively upon terrestrial insects that fall upon the water surface, according to Hankinson's unpublished field observations and his food-studies in Illinois (Hankinson, '10, p. 30). Ellis ('14, p. 58) says: "The adult is a voracious fish feeding upon surface insects, aquatic insects, small fishes and even the spawn of other fishes." Weed and McAtee ('15, p. 10) found only damselfly nymphs in the stomach and intestines. Abbott ('90, p. 409) states that this dace feeds upon insects and minute mollusks.

Distribution Records. We obtained only 24 specimens of this species in our field work on Oneida Lake. Of these, No. 120 is from Big Bay Shoal, near Belknaps Landing, September 6, 1915; and No. 453 is from the west side of Bernhard Bay, June 26, 1916, taken among water plants. These consist of single specimens only, about $1\frac{3}{4}$ inches long. The remaining specimens are from small tributary streams near the lake shore, as follows: No. 142, from Frederick Creek, between the railway track and the Oneida Hatchery, September 8, 1915; No. 458, from a small stream entering on the west side of East Potter Bay, June 27, 1916, consisting of 2 specimens about $2\frac{1}{4}$ inches long; No. 553, from a small swift rocky stream flowing into the lake at West Vienna, July 14, 1916; No. 593, from the small rapid stream at North Bay, July 21, 1916; 3 specimens about $1\frac{3}{4}$ inches long; and No. 594, from a rocky pool in a small stream $1\frac{1}{2}$ miles east of West Vienna, July 21, 1916. These records are clearly indicative of the rare occurrence of this typically small stream species in the Lake.

Enemies and Disease. We have found only a few references to the predacious enemies of this species. Forbes ('88a, p. 511) records it from the stomach of the Pike Perch (*S. vitreum*). Hankinson ('16, p. 23) found the worm *Echinorhynchus* in the digestive canal. Six Oneida Lake specimens from our collection were badly infested with parasites in the skin (No. 458, two specimens; No. 593, three specimens; No. 594, one specimen). Two specimens (No. 302) from Onondaga Creek were similarly infested with what are probably parasitic worms. Ellis ('14, Pl. V, fig. 26) figures this fish with numerous trematodes in the skin. Hankinson ('16, p. 22) found the sporozoan *Myxobolus* infesting Michigan specimens.

Angling Notes. The destruction of Brook Trout by the Chub is counter-balanced in part by its value as bait. Evermann ('01, p. 318) says: "There is no fish of which the Black Bass is more fond than this same Chub, and for bass fishing there is no better bait. It is full of tenacity of life and seldom dies either in the bucket or on the hook. It is active and moves about when on the hook in the most attractive manner. For bass fishing too large a Chub must not be chosen. . . . but it is not often worth while to use Chubs more than 6 inches in length;

those 4 inches or under are apt to prove far more killing." Kendall and Goldsborough ('08, p. 29) state that "this chub readily takes a hook baited with worm, piece of fish, or any kind of flesh and frequently an artificial fly."

References. Abbott, '90; Allen, '14; Baker, '16; Ellis, '14; Evermann, '01; Forbes, '83, '88a; Fowler, '13; Greeley, '27; Hankinson, '08, '09, '10, '13; Kendall and Goldsborough, '08; McAtee, '15; Reighard, '10; Shelford, '13; Weed and McAtee, '15; Wright and Allen, '13.

Notropis heterodon (Cope). BLACK-CHINNED MINNOW. This is one of the three or four species of minnow found in Oneida Lake that are alike in certain features, and by which they differ from all other minnows in the lake. These are: small size, ordinarily about 2 inches and never exceeding 3 inches in length; subterete form; and scales large everywhere on the body. Black-chinned Minnows differ from the others of this group in having the anterior edge of the lower jaw bordered with black, whence its common name. The species is apparently scarce in Oneida Lake.

Breeding and Life History. Wright and Allen ('13, p. 3) give the breeding time for Ithaca, N. Y., as May 8th to June 12th. Forbes and Richardson ('09, p. 136) say that the species spawns in May and June in central Illinois. Hankinson ('08, p. 206) took three gravid females on June 16, at Walnut Lake, Michigan.

Habitat. This minnow appears to prefer lakes to streams (Forbes and Richardson, '09, p. 136 and p. cx), and bottoms of mud and sand. Hankinson ('08, p. 206) found them especially common where vegetation is abundant in Walnut Lake.

Food. A variety of food is eaten. Forbes ('83, p. 129) found in eighteen specimens, a little mud, some flowers and seeds, comprising about a tenth of the food, traces of filamentous algae, some snails, insects (chiefly *Chironomus*), many entomostracans (58%), and a few other organisms including some rotifers and protozoans. Hankinson ('08, p. 206) found them at Walnut Lake, Michigan, eating algae and *Entomostraca*, and adult midges (*Chironomus*) when there was a flight of them. DeRyke ('22, pp. 10, 14 and 16) found this minnow eating unicellular and filamentous algae, and wings and other fragments of adult insects, including a neuropterous form. One specimen contained 14 fish eggs. Three specimens, 2-3 inches long, were examined. Pearse ('18, p. 289; '21a, p. 37) reports on food examinations of this species from Wisconsin Lakes. Entomostracans, chironomids (larvae, pupae and adults), oligochaete worms, and filamentous algae composed the stomach contents. Greeley ('27, p. 59) notes that the food of a specimen from Black Creek, Monroe Co., N. Y., consisted of small crustaceans (*Chydorinae*).

Distribution Records. Three specimens (No. 353) were taken in Oneida Lake at Brewerton, April 29, 1916, and on October 16, 1916, twelve (No. 622) were caught at Brewerton by R. O. Bassett.

Economics. Evermann ('01, p. 321 and p. 322) says it is similar to the Cayuga Minnow in value and is used as a bait minnow. (See description of *N. Cayuga*.)

References. Evermann, '01; DeRyke, '22; Forbes, '83; Forbes and Richardson, '09; Greeley, '27; Hankinson, '08; Pearse, '18; '21a; Wright and Allen, '13.

Notropis bifrenatus Cope. BRIDLED MINNOW. This very attractive little fish is one of the smallest species of minnow found in Oneida Lake. It closely resembles the Black-chinned Minnow and the Black-nosed Shiner. In fact these three species are readily confused with each other, since they are all of similar size and are much alike in form, with a prominent lateral band. The Black-chinned Minnow is, however, easily distinguished by the considerable amount of black pigment on the chin, which is nearly absent on the other two. The Bridled and Cayuga Minnows have been very generally confused, and according to Hubbs ('26, p. 40), *Notropis cayuga* described by Meek ('89, p. 305) was *Notropis bifrenatus*. Our collections revealed that the Bridled Minnow is the most abundant of these little black-sided minnows.

Breeding Habits and Life History. Fowler ('09, p. 531) gives the spawning time as May and June. He states that the sexes are alike in coloration and that the young are very similar to the adults. However, at breeding time gravid females are easily distinguished from the adult males by their deeper bodies. The maximum size of the fish is about two inches. All of our Oneida Lake specimens were very uniform in length, near $1\frac{3}{4}$ inches.

Habitat. In Oneida Lake the Bridled Minnow seemed to prefer shallow water with abundant vegetation, and it was often found about the water willow (*Dianthera*) patches, over both sandy and muddy bottom. In streams close to the lake, they were taken both in quiet and in running water. Along the shore of Frenchman's Island we found them very abundant about the water willow growths, and associated with Blunt-nosed Minnows, Barred Killifish, Johnny Darters, the young of the Common Sucker, and young Rock Bass. Fowler ('09, p. 531) says this species is found in clear, rather still water, in schools of moderate size and associated with other small fish. The same author ('05, p. 140) says the species is locally abundant in small creeks where there is deep water with gentle current. He also says ('14b, p. 3) that it is found in quiet waters associated with Golden Shiners, Common Suckers, Chub Suckers, Common Sunfish, Long-eared Sunfish (*Lepomis auritus*), and turtles and frogs. In the Palisades Interstate Park, Hankinson found Bridled Minnows abundant only in places where there was an abundant growth of water plants (Adams, Hankinson, and Kendall, '19, pp. 197, 201, 202) and where the water was clear and quiet.

Distribution Records. No. 5, South Bay; No. 76, Scriba Creek; No. 79, Johnson's Bay; No. 83, Phillip's Landing; Nos. 81, 87, 88, Chittenango Creek; No. 121, Ice House Bay; Nos. 124, 482, Fairchild Bay; Nos. 305, 314, 617, 626, Brewerton; No. 425, Dakin Bay; No. 475, Short Point Bay; No. 543, Frenchman's Island.

Enemies and Disease. Abbott ('75, p. 834) found *Roccus lineatus* ("Rock Fish") feeding upon *Notropis bifrenatus*. Fowler ('13, p. 15) reports it taken by Kingfishers and thinks that very probably it is eaten also by Pied-billed Grebes (p. 8).

Economic Notes and Angling. This little fish would doubtless prove a suitable bait for Perch, Rock Bass, or Crappie, since Hankinson has found species similar to it to be greedily taken by these fishes in Michigan lakes. Bean ('03, p. 136) says that it is a useful bait particularly for Black Bass.

References. Abbott, '78, '84; Bean, '92, '03; Fowler, '05, '09; Jordan and Evermann, '96; Nichols and Gregory, '18.

Notropis heterolepis (Eigenmann and Eigenmann). BLACK-NOSE SHINER OR CAYUGA MINNOW. This is one of the small minnows that has been variously confused with similar forms under the name of Cayuga Minnow (*Notropis cayuga*). It is apparently scarce in the lake.

Breeding and Life History. This is very probably the species which Forbes and Richardson ('09, p. 133) refer to as *Notropis cayuga*, and state that females near spawning were taken from June 5 to August 1.

Habitat. The three specimens taken in the Oneida Lake region were caught near the mouth of a small tributary stream of the lake. None was found in the many collections made in the lake. Evermann and Clark found it exceedingly abundant in the shallow shore waters of Lake Maxinkuckee in the fall ('20, p. 285), and they describe a shoreward migration of this and other species at that season. Forbes and Richardson ('09, p. 133) found "*Notropis cayuga*," which was very probably *N. heterolepis*, most abundant in creeks in Illinois, but they note its occurrence also in the glacial lakes of that state.

Food. Few examinations of the food of this species have been made. Hankinson ('15, p. 147; '08, p. 205) found that alimentary tracts of Michigan Black-nose Shiners contained Entomostraca, insects (including *Chironomus* larvae), filamentous algae, and diatoms. Evermann and Clark ('20, p. 349) found various species of Entomostraca and several different kinds of diatoms, in specimens from Lost Lake, Indiana.

Dr. Emmeline Moore ('22, p. 56) includes Cayuga Minnows among those that characteristically feed on vegetable food, eating principally microscopic plants. Details of the food of thirty-eight specimens are given in her table on page 53. Plankton algae, filamentous algae and diatoms were eaten abundantly. Vascular plants, protozoans, rotifers and entomostracans were also taken in important amounts, and midge larvae and ephemerid nymphs in small amounts. Since *Notropis bifrenatus* and *N. heterolepis* have been confused in the past in waters where they occur together, as in Cayuga Lake (Hubbs, '26, p. 41), since *N. bifrenatus* was not recorded from Lake George by Sibley, ('22), and since Lake George is within the range of this species, it seems probable that the data given by Dr. Moore pertain to the food of both species.

Distribution Records. Only three specimens (No. 593) of this species were recorded and these were taken near the mouth of a small stream tributary to Oneida Lake.

Economics and Angling. Evermann ('01, p. 321) says: "It reaches a length of but 2 or 3 inches, which somewhat militates against its being of much value as a bait minnow. But used singly for Yellow Perch or, with two or more on a hook, for Yellow Pike, it is usually quite effective; and some anglers find the larger ones very good for the smaller bass, particularly in still fishing for the Small-mouthed Black Bass. For Yellow Perch, there is no better minnow, if the larger ones are selected."

References. Ellis, '14; Evermann, '01; Evermann and Clark, '20; Forbes and Richardson, '09; Hankinson, '08, '15; Moore, '22.

Notropis deliciosus (Girard). STRAW-COLORED MINNOW. This species appeared to be very scarce in Oneida Lake at the time our collections were made. It is very similar to the Black-nosed, the Black-chinned, and the Bridled Minnows, but the dark lateral stripe, is more prominent in these three forms. It is the species that has been treated under the name of *Notropis blennius* (Hubbs, '26, p. 42), and has been confused in the literature with the very similar *Notropis volucellus* (Cope).

Breeding Habits and Life History. There is little information on record that applies with certainty to this species. Hubbs ('23, p. 213) has made a careful study of the species in Douglas Lake, Michigan. He found these fishes coming to the shoals July 7; and that they spawned there was evident from the fact that newly-hatched young began to appear there later, continuing on into August. While the species apparently breeds late in the season in Douglas Lake, in more southern waters like Oneida Lake, spawning probably occurs earlier.

Distribution Records. Only three specimens (No. 416) were secured and these were taken at Lakeport Bay, June 22, 1916.

References. Hubbs, '23, '26; Hubbs and Greene, '28.

Notropis dorsalis (Agassiz). GILBERT'S MINNOW. The Gilbert's Minnow is abundant, at least locally, in Oneida Lake. We took a few in 1916, but in 1927 we found large numbers at Sylvan Beach. It is possible that the species has increased its numbers in recent years.

Breeding Habits and Life History. Gravid females were found by Forbes and Richardson ('09, p. 140) in the latter part of June.

Habitat. The sandy shallows of Sylvan Beach near the base of the pier, at the mouth of Fish Creek, seemed to be a favorable habitat for the young of this species. Here large numbers of them were associated with adult *Notropis atherinoides* and *N. rubrifrons*. Many were also found landlocked in wave formed, isolated pools (Coll. No. 4270) on the sandy beach at the east end of the lake (Figs. 217, 218). Greeley ('27, p. 59) reports that this fish inhabits the larger, warm tributaries of the Genesee River. Forbes and Richardson ('09, pp. 140 and cx) consider the species as one inhabiting small rivers and creeks. Jordan and Evermann ('96, p. 266) say it is found in muddy streams from the Des Moines River to the Platte. Meek ('92, p. 233) reports these minnows as living in clear, running water, in Iowa, and Evermann and Cox ('96, p. 404), that they appear to prefer small streams or rivulets with sandy bottom and with some current.

Food. Greeley ('27, p. 59) examined the food of one specimen 2 1/16 inches long and found it to consist of chironomid larvae, fragments of three other insects, and some diatoms.

Distribution Records. No. 501, Lewis Point, July 5, 1916; No. 4200, Maple Bay, October 4, 1920; No. 4270 and 4271, Sylvan Beach, September 9, 1927. About 150 specimens were taken.

References. Evermann and Cox, '96; Forbes and Richardson, '09; Greeley, '27; Jordan and Evermann, '96; Meek, '92.

Notropis hudsonius (DeWitt Clinton). SPOT-TAILED MINNOW, SPAWNEATER, SHINER. The Spot-tailed Minnow appears from our studies to be the most

abundant and most generally distributed species of minnow in the shallow waters of Oneida Lake, at least during the summer when most of our collections were made. It is easily identified by its somewhat slender form, rather large scales, prominent eyes, and absence of conspicuous markings, except a distinct black spot at the base of the caudal fin. This feature is very well developed in Oneida Lake examples. Most of the fish we took were from 2 to 3 inches long, but a few large ones, $3\frac{1}{2}$ to $4\frac{1}{2}$ inches long, were caught, also. The species was described by Governor DeWitt Clinton of New York, in 1824, as *Clupea hudsonia* (Jordan and Evermann, '96, p. 269; Evermann, '01, p. 322), from a specimen taken in the Hudson River.

Breeding Habits and Life History. Young fish of this species appeared abundantly in schools in July, 1916, in shallow water where there was considerable water willow (*Dianthera*) and other aquatic vegetation (Nos. 529, 591, and 599). It is likely that spawning occurs in spring or early summer, judging from the size of specimens taken at that time. Wright and Allen ('13, p. 5) give the breeding time for Ithaca, N. Y., as April 25 through May, and the breeding place as gravelly riffles. None of the many specimens we took in summer showed external evidence of spawning, nor did the twenty-two that were dissected. It seems, therefore, that the species must breed in spring, a season during which we did very little collecting. Hubbs ('24, p. 208) found newly hatched young of this species in Douglas Lake, Michigan, from about June 10 to 20. He studied their growth up to July 16 and found a rather uniform rate of about 7 mm a day for the young. By July 16 these young of the year ranged in size from 15 mm to 37 mm.

Habitat. Spot-tailed Minnows were most often found on sandy or rocky shallows with scant vegetation (Nos. 447, 463, 483, 501, 502, 550, 599). The results of our two summers' intensive collecting make it appear that these minnows go to deep water in early autumn, since they were numerous in shallow water during July and August, 1916. The large fish appear to avoid thick growths of water-plants, while small ones may be numerous in such places (Nos. 98 and 529). Extensive shoals without plants seem little frequented, except when situated near plant growths. The largest collection (No. 501) was made in the bay west of Lewis Point, on July 5, 1916, when 381 individuals were taken in one haul with the minnow seine. Another large collection (No. 447) of 47 fish, was made at East Potter Bay on June 27, 1916, in the mouth of a small creek, where lake conditions prevailed, and where the fish may have gone on account of a storm that raged prior to our collecting there. Ordinarily they were not found in streams. None were found in the streams at Constantia, and but a very few (No. 553) at West Vienna and Douglas Creek (No. 416). The species appears distinctly to be one of large rivers and lakes (Forbes and Richardson, '09, p. 142; Forbes, '83, p. 127; Meek and Hildebrand, '10, p. 272; Bean, '92, p. 38).

Food. Forbes and Richardson ('09, p. 143) say: "It is a typical minnow in its food, depending on insects, crustaceans, and vegetation, the latter partly algae of the filamentous forms and partly fragments of aquatic plants. This general statement does not indicate the variety of its resources or the seeming indifference with which it will fill itself with one or the other kind of food which it finds most abundant." Two, for example, had eaten chiefly algae; 3 had eaten only terres-



Fig. 203. Interior of swamp bordering Oneida Lake East of South Bay. June 29, 1916.



Fig. 204. Border of water willow (*Dianthera*) near mouth of Oneida River at Brewerton. July 25, 1916.



Fig. 205. *Castalia* zone and marginal growth of narrow leaf cat-tail (*Typha angustifolia*) at Poddygut Bay. July 16, 1916.



Fig. 206. *Castalia* growth, Poddygut Bay. July 16, 1916.

trial snout beetles; 2 had taken nothing but Entomostraca (*Cypris*); and 7 had fed largely on a variety of vegetable matter. The nymphs of May-flies (Ephemera) made up more than three-fourths of the food of three other specimens. Two had eaten small fish. Reighard ('15, p. 227) observed immature fish in Douglas Lake feeding on a cladoceran, *Chydorus*, the form which makes up the bulk of the food of young perch and the associated suckers. He says: "The short, slender close-set gill rakers with the narrow gill opening make an excellent apparatus for the capture of these small Crustacea. The roof and sides of the mouth and the tongue have many short papillae set in curved longitudinal rows, and these may serve to hold the Crustacea while permitting water to pass backward." The diversity of the food and these special oral adjustments may be important reasons why the species is so abundant and generally distributed in Oneida Lake.

The large collection of 381 individuals (No. 501) of this species made near Lewis Point was undoubtedly due to the great numbers of dead or dying May-flies in the water there, forming a thick floating mass along the shore and a windrow upon it. Apparently all of the many fish caught had been eating these insects, the purplish fragments of which showed distinctly through the body wall of nearly all of the fishes examined. The name "Spawn Eater" applied to this species is said to have arisen from its habit of eating eggs of other fishes (DeKay, '42, p. 206). Greeley ('27, p. 59) found the food of a small specimen from the Genesee River, New York, to consist of fragments of about 15 cladocerans.

Distribution Records. The Spot-tailed Minnow appeared scarce and locally distributed in the shallow waters where we collected from August 31 to September 9, 1915. Only two collections contained them: No. 90, 2 fish, and No. 92, 14 fish, both from Maple Bay. In June and July, 1916, large numbers of these minnows were taken in the following collections: No. 400, Froher Bay; No. 401, Billington Bay; No. 403, Shackleton Point; No. 406, Leete Island; No. 416, Lakeport; Nos. 419, 422, Mathews Point; Nos. 427, 428, Dakin Bay; 434, Norcross Point; No. 441, Taft Bay; No. 447, East Potter Bay; No. 453, Bernhard Bay; No. 456, West Potter Bay; Nos. 459, 463, 464, East Potter Bay; No. 470, Cleveland Bay; No. 475, Lower South Bay; No. 483, Fairchild Bay; No. 491, Three Mile Bay; No. 498, Messenger Bay; Nos. 500, 501, 502, Lewis Point; No. 507, Upper South Bay; Nos. 517, 518, Sylvan Beach; No. 522, Frenchman's Island; No. 523, Short Point Bay; Nos. 529, 539, Dunham Island; No. 550, Godfrey Point; No. 552, West Vienna; No. 577, Three Mile Bay; No. 591, Sylvan Beach; No. 599, Brewerton; No. 611, Lower South Bay. One fall collection, No. 5, made October 31, 1914, contained 15 of these fish.

Enemies and Disease. More diseased specimens of the Spot-tailed Minnow were found than of any other species of minnow, which was probably to be explained by their greater abundance (Nos. 400, 403, 416, 422, 427, 428, 432, 448, 483, 498, 501, 503, 526, 540). Frequently dead examples were discovered and these were usually large ones, about four inches in length. Evermann ('01, p. 323) says that the scales of this form rub off easily, thus rendering it susceptible to *Saprolegnia*. The species was reported to him to be the principal food of the Muskallunge in Chautauqua Lake. Fowler ('13) found the variety *N. h. amarus* taken by the Loon (*Gavia immer*) (p. 8), Common Tern (*Sterna hirundo*) (p. 9),

American Merganser (*Mergus americanus*) (p. 9), and Kingfisher (*Ceryle alcyon*) (p. 15). One was found in the stomach of a Chain Pickerel taken at Fairchild Bay, Oneida Lake, June 30, 1916.

Economic Relations. Evermann ('01, p. 323) considers it a bait-minnow of high rank; on Lake Ontario and among the Thousand Islands it is regarded as the best for bass, and at Chautauqua Lake it is popular Muskallunge bait. He further remarks (l.c.): "In northern Indiana it is a good general purpose minnow. The smaller ones are good for Yellow Perch; those of medium size are excellent for bass; while the largest are used for the Common Pike and the Pike Perch. Its bright silvery color makes it an attractive bait and it is active and vigorous on the hook, swimming clear of vegetation and at a good distance above the bottom when possible. It is not so hardy as it should be." Jordan and Evermann ('03, p. xli) also include it in the list of fishes that make superior live bait. Evermann and Kendall ('01, p. 483) consider it one of the most useful bait-minnows in New York, and Greeley ('27, p. 59) says that near the mouth of the Genesee River at Lake Ontario it is used for Yellow Perch bait. It is probably a useful fish in Oneida Lake, furnishing not only abundant bait, but also food for larger species of fish and with which, because of its varied diet, it probably does not seriously compete, notwithstanding its abundance.

References. Bean, '92; Clemens, '24; DeKay, '42; Evermann, '01; Evermann and Kendall, '01; Fowler, '13; Forbes, '83; Forbes and Richardson, '09; Greeley, '27; Jordan and Evermann, '96, '03; Meek and Hildebrand, '10; Reighard, '15; Wright and Allen, '13.

Notropis whipplii (Girard). SILVERFIN MINNOW, STEEL-COLORED MINNOW. Silverfins are uncommon in Oneida Lake, and are probably not distinguished from Common Shiners, *Notropis cornutus*, by anglers who use the Lake minnows for bait. Large examples differ from shiners by having one or two indistinct blackish spots on the membrane of the posterior part of the dorsal fin. The Silverfin also has a more compressed and more evenly elliptical body, and is withal a more trim and handsome fish.

Breeding and Life History. Females about to spawn were taken by Forbes and Richardson ('09, p. 147) in Illinois, from May 21 to June 12; and others that had not deposited eggs were taken as late as the middle of August. Wright and Allen ('13, p. 5) give the spawning time for Ithaca, New York, as May 21 to June 28, and say that gravelly riffles are used for the purpose. Breeding males have numerous small tubercles on the head and on the sides just back of it. They develop a satin-white pigment in the fins and along the belly, which has given the name "Silverfin" to this species. Evermann and Clark ('20, Vol. 1., p. 355) say that the species evidently spawns, in Lake Maxinkuckee, toward the end of July.

Habitat. The species is evidently one of streams rather than lakes (Forbes and Richardson, '09, p. 146), preferring rapid water. Evermann ('01, p. 324) says it delights in the rush and swirl of waters on riffles.

Food. Forbes and Richardson ('09, p. 146) found that two-thirds of the food of thirty-three specimens examined consisted of insects, nearly half of which

were terrestrial; three specimens had eaten small fishes and a mixture of vegetable matter. Evermann ('01, p. 324) says it feeds upon insect larvae and small crustaceans which it finds among the stones or adhering to the potamogetons and other water plants that grow in such places. Evermann and Clark ('20, pp. 295, 355) record insect larvae, water mites and plankton from two specimens. Cole ('05, p. 600) found this minnow eating the spawn of Carp. Greeley ('27, p. 59) reports that the food found in a specimen from Canaseraga Creek, in New York State, consisted only of an *Eristalis* larva and an adult insect.

Distribution Records. Thirty specimens were taken in Oneida Lake and two in Douglas Creek. These were distributed through twelve collections, as follows: No. 90, Maple Bay, Sept. 2, 1915; No. 400, Froher Bay, June 20, 1916; No. 401, Billington Bay, June 22, 1916; No. 413, Douglas Creek, June 22, 1916; No. 148, Lakeport Bay, June 22, 1916; No. 463, East Potter Bay, June 28, 1916; Nos. 500, 501, 502, Lewis Point, July 5, 1916; and Nos. 517, 518, Sylvan Beach, July 6, 1916.

Enemies and Disease. Bean ('92, p. 40) says it is useful as food for larger fishes. Fowler ('13) found it eaten by the Dabchick, the Loon, the American Merganser, the Green Heron, and the Kingfisher; and Evermann and Clark ('20, p. 297) mention it as eaten by Rock Bass.

Economic Relations. The scarcity of Silverfins makes this minnow of little economic interest in Oneida Lake. It does well in an aquarium (Bean, '03, p. 144) and serves well as bait. Evermann ('01, p. 324) declares "It is very active when on the hook, which, with its bright silvery coloration, should make it attractive to Black Bass. It lives well in a live-box, minnow bucket, and on the hook."

References. Baker, '16; Bean, '92, '03; Cole, '05; Evermann, '01; Evermann and Clark, '20; Forbes and Richardson, '09; Fowler, '13; Greeley, '27; Wright and Allen, '13.

Notropis atherinoides Rafinesque. EMERALD MINNOW, LAKE SHINER, ROSY MINNOW, LAKE SILVERSIDES, BUCKEYE SHINER. This is perhaps the most beautiful of the minnows in Oneida Lake, where it is abundant. It is not represented in many of our collections, probably because they were made mostly in shallow water in summer, when the species evidently frequents the deeper waters of the lake. It is commonly known as the Buckeye Shiner, by Oneida Lake fishermen. It is usually met with in large schools with few or no other kinds of fish among them, and in clear, plant-free waters near the shore of the lake. This species and the Spot-tailed Minnow are the characteristic shiners of the sandy shoals of the Great Lakes, and they possibly came into Oneida Lake from Lake Ontario (Bean, '07, p. 193). It is easily distinguished from other Oneida Lake minnows by its elongated compressed body with a broad subdued band on each side, more distinct behind and ending near the head, and by a snout scarcely longer than its relatively large eye. The dorsal fin is placed noticeably back of the pelvic fins, a feature that distinguishes the Emerald and Rosy-faced Minnows from other Oneida Lake minnows of similar size and form.

Breeding and Life History. Females about to spawn were found by Forbes and Richardson ('09, p. 153) from the middle of May to June 1. They found no tuberculate males. Spring males have the snout rose colored (Jordan and

Evermann, '96, p. 293). Hubbs ('22) has made the most important contributions to the life history of *Notropis atherinoides* that we have seen, but his findings were largely on the growth of the species and the variation of the number of vertebrae. His studies were based on examination of many hundreds of fish collected at Jackson Park lagoon, Chicago. Fish of the year taken in December ranged from about 1 to $3\frac{1}{2}$ inches in length, $1\frac{3}{4}$ inches being about the average length. Fish in their second year, ranged from about $2\frac{3}{4}$ to $3\frac{1}{2}$ inches, with an average near three inches.

Habitat. It was very evident that in Oneida Lake this species prefers open waters and avoids thickets of water plants, for few if any were taken where such were present. At Sylvan Beach, on July 6, 1916, Emerald Minnows were abundant in open water, over sandy bottom near shore, where they appeared to be the only species present, while other fishes were numerous about the vegetation covered areas in the same locality. They appeared common in Douglas Creek where fifty specimens (No. 413) were caught in shallow, rapid, turbid water with pebble and sand bottom.

Jordan and Evermann ('96, p. 293) say that it is abundant in lakes, quiet waters and river channels. Forbes and Richardson ('09, p. 152) find it preferring larger rivers and lakes, a good current and clear bottom. Bean ('03, p. 148) states that it is abundant in lakes and in the rapids of rivers, and ('07, p. 193) mentions it ascending Scriba Creek and Frederick Creek at Constantia, in spring and fall, in great schools, perhaps to spawn or to feed on Pike Perch eggs, or to seek more open water than the lake affords. He says the species is very hardy in cold water but does not endure warm water in summer.

Food. Forbes and Richardson ('09, p. 153) and Forbes ('83, p. 130) say that this species moves and feeds in large schools, thousands being frequently seen together near the surface. The food of eighteen specimens from northern Illinois consisted principally of insects, nearly two-thirds of which were terrestrial species, and the remainder chiefly case-worms and nymphs of ephemerids. Three had eaten only Entomostraca; one contained filamentous algae, and another a minute fish. Clemens ('24, p. 112) reports on the food of eleven of these minnows in which aquatic insects and Chironomidae formed a prominent part of the food. Terrestrial insects were abundantly represented, while entomostracans, arachnids and oligochaete worms had also been eaten. Three had fed extensively on fish eggs. Greeley ('27, p. 60) found insect remains and an adult midge (Chironomidae) in a small Emerald Minnow from the Genesee River.

Distribution Records. Lake collections from shallow water made in summer and containing ten or more examples of this species are as follows: No. 77, Bullhead Bay; No. 441, Taft Bay; No. 463, East Potter Bay; No. 470, Bay east of Cleveland; No. 550, Godfrey Point. Collection No. 470 was a very large one made June 28, 1917, from a large compact school of these minnows in two to three feet of water, over rock and sand bottom some fifty feet from shore, near Cleveland. Another large collection (No. 4271, Fig. 36) was made at Sylvan Beach, September 9, 1927. Smaller summer collections from the lake are: No. 406, Leete Island; Nos. 428, 430, Dakin Bay; No. 448, Taft Bay; No. 501, Bay near Lewis Point; No. 507, Upper South Bay; No. 529, Dunham Island.

They were found in three stream collections; No. 76, Scriba Creek; No. 413, Douglas Creek; No. 511, Oneida Creek. In a fall collection made in October, 1916, one Emerald Minnow was found (No. 622).

Enemies and Disease. Bean ('07, p. 193) says that it furnishes abundant and dainty food for game species. It appears to be very free from disease, at least in Oneida Lake, for only two collections contained diseased fish; No. 508, three specimens, and No. 518, one specimen. Each of these fish had a whitish area or zone on the body, apparently produced by *Saprolegnia*. This was on the caudal peduncle in each of the three of collection No. 508; the caudal fin was completely destroyed in two, and nearly so in the third. On October 3, 1920, two with the caudal peduncle diseased were taken at Maple Bay.

Economic Relations and Angling. This species appears to be valuable as a bait minnow chiefly on account of its abundance, and it is easily caught in large numbers. Hankinson found it plentiful in Lakes Michigan and Huron, where it is taken by a few dips near shore with a small seine or dip-net, in such numbers as to furnish enough Perch bait for several hours of fishing. This and the Spot-tailed Minnow appear to be the common minnows sold to anglers by bait fishermen about the Great Lakes (Forbes and Richardson, '09, p. 152; Evermann, '01, p. 328). Its silvery sides make it attractive bait, but it dies quickly and its scales come off easily. Anglers have informed us that it is of little value for fishing in Oneida Lake. Evermann ('01, p. 328), however, notes that with careful handling it makes a very good bait for Black Bass or Yellow Perch. Bean ('07, p. 193) also considers it good bait for the Black Basses and Pike Perch. This minnow is said to be very hardy in cold water (l.c.) so that it is a useful bait in winter, and, in fact, it is the principal bait used in perch fishing through the ice at Oneida Lake.

It furnishes food for the larger fish, but it is suspected of eating the eggs of Pike Perch. Bean says (l.c.): "If the experiment now in progress to establish it in trout waters proves successful, we may expect results highly beneficial to fish culture, as trout food is often costly and difficult to obtain in good condition." Foreman Scriba, formerly of Constantia Hatchery, shipped 1,000 of these shiners to the Adirondack Hatchery and 1,000 to the Delaware, N. Y., Hatchery for these experiments (l.c., pp. 181, 186). Macdonald ('27, p. 106) reports 15,000 distributed by the hatchery at Constantia in 1926. However, if Emerald Minnows eat spawn, some caution should be exercised in introducing them into trout waters. Before such introduction is attempted a careful study of the food of the species should be made. Since this minnow and the Brook Trout both feed on aquatic insects and Entomostraca (Forbes and Richardson, '09, p. 153; Forbes, '83, p. 130; Needham, '03, p. 205) it is possible that, if planted together in small streams, a food competition unfavorable to the trout may result. These fish are excellent for aquaria. Their glistening sides, unique form and graceful movements make them attractive, and they live well if given good clear water frequently. A prepared food containing insect material should be given them. Hankinson has kept them for more than six months in simple aquaria.

References. Bean, '03, '07; Clemens, '24; Evermann, '01; Forbes, '83; Forbes and Richardson, '09; Fowler, '09; Greeley, '27; Jordan and Evermann, '96; Macdonald, '27; Needham, '03.

Notropis rubrifrons (Cope). ROSY-FACED MINNOW. This minnow is abundant in Oneida Lake and in streams connected with it. Breeding individuals found in streams and to some extent in the lake, with their bodies flushed with red and with glistening steel-blue lateral stripes, are perhaps the most beautiful small fish of the region. The species resembles the Emerald Minnow closely, but it has a longer, more pointed snout, and usually a more slender body. The dorsal fin is noticeably farther back than the pelvic fins, as in the Emerald Minnow.

Breeding. It probably spawns in spring or early summer in streams connected with the lake, for we found fish with breeding colors, nuptial tubercles, and highly developed reproductive glands abundant in these streams at that time (No. 425, Dakin Bay Creek, June 23, 1916; No. 460, Black Creek, June 27, 1916; No. 413, Douglas Creek, June 22, 1916; No. 593, creek entering North Bay, July 21, 1916). No breeding specimens of this species were included in our collections made in early September. Forbes and Richardson ('09, p. 154) state that the breeding males have many fine tubercles on the head and fore part of the body, and that weak tubercles are sometimes possessed by breeding females also. This corresponds in general with our observations, except that males have tubercles over the whole body, even on the belly in some cases, and they are similarly distributed in females; and in the case of two female specimens which we closely examined they were as large but not so numerous as those on the males. Dan Miller, Foreman of the Constantia Hatchery, reports that spawn came out very freely from minnows of this species that he was using for bait on July 20, 1914 (Bean, '15, p. 351). Osburn ('01, p. 58) observed females with ripe eggs, in large schools over clear, gravelly places on riffles, on May 24, 1898, a date which agrees with the observations of Forbes and Richardson ('09, p. 154).

Habitat. These fish were much more common in our lake collections made in September, 1915, than in those made in June and July, 1916. These collections were made in shallow water, no data being obtained on the species in deep water. We found it common in the creeks at all times. It is evidently more of a stream fish than a lake fish (Forbes and Richardson, '09, p. 154; Fowler, '08, p. 543; Jordan and Evermann, '96, p. 295). We found them very abundant on the sandy shallows of Sylvan Beach, associated with *N. atherinoides*, September 9, 1927 (No. 4271).

Food. Three specimens (No. 460) out of seven examined from Black Creek, Cleveland, were found to contain food. Two were males and one a female; all had pearl organs and highly developed gonads. Insects, including adult and pupal chironomids, had been eaten by all of them. Two Nematodes, probably parasites, were found in one fish, and some filamentous algae had been taken by another. Three young, about an inch long, were examined by Greeley ('27, p. 60) who found in their intestines caddice worms, 30%; May-fly nymphs, 20%; adult midges, 20%; black fly larvae, 20%; and green algae (*Spirogyra*), 10%.

Distribution Records. The following were taken in September, 1915, in the shallow marginal water of the lake: No. 77, Bullhead Bay; No. 78, Baker Point; No. 86, Paddygut Bay; Nos. 90, 92, Maple Bay; No. 105, Muskrat Bay. Many of these minnows (41 to 90 specimens) were in each of the above mentioned collections, except Nos. 86 and 90 which contained 8 and 5 respectively. In

September, collecting was done in but two creeks where conditions were favorable (rapid, clear water) for this species. At Scriba Creek, Nos. 76 and 52 were taken, and in a portion of Chittenango Creek, two (No. 88) were caught. This small number was undoubtedly due to difficulty of collecting here, for many fish were seen which appeared to be of this species. In June and July, 1916, only a very few were caught in the lake and these were in five of our shallow water collections: No. 441, 1 fish; No. 470, 3 fish; No. 483, 1 fish; No. 552, 3 fish; No. 603, 1 fish. In creeks at this time, we took many which were for the most part strongly pigmented examples, including many rose-flushed breeding males. These were, No. 425, 428, 430, Dakin Bay Creek, 18 fish in all; No. 413, Douglas Creek, 109 fish; No. 460, Black Creek, 54 fish; No. 593, North Bay Creek, 80 fish. A spring collection, No. 353, had one fish, and a fall collection, No. 622, had three. At Sylvan Beach, September 9, 1927, Dence and Hankinson caught many of them in one seine haul, of which 305 were added to the collection. They were associated with *Notropis atherinoides*. One thousand two hundred and fifty were taken in this same haul. These were preserved as part of collection No. 4271. The haul is shown as Figure 219. Seven others were taken in isolated pools on the beach at the east end of the lake (No. 4270). Dan Miller reported this fish from Oneida Lake on July 6, 1914 (Bean, '15, p. 351). He said these minnows had never been seen in the lake before and presumed that they have worked up from Lake Ontario through the Barge Canal and Oneida River. It seems probable, though, that this minnow has been overlooked, on account of its close resemblance to the Emerald Minnow.

Disease. One diseased fish (No. 413) from Douglas Creek is in our collections. Its gills on both sides have large swellings, similar in size and position, and extruding prominently from the gill openings. Possibly the kind of nematode worms found in the intestine of No. 460 were here represented.

Economic Relations and Angling. Evermann ('01, p. 328) declares that for Yellow Perch, Crappie, Calico Bass, Warmouth, and both species of black bass up to 1½ to 2 lbs. in weight, "there is no better lure than this exquisite little minnow." Rosy-faced Minnows are excellent for the aquarium, especially when in their breeding colors. We kept a number of them for about a week, in an aquarium outdoors, without giving them any particular care.

References. Bean, '15; Evermann, '01; Forbes and Richardson, '09; Fowler, '08, '09; Greeley, '27; Jordan and Evermann, '96; Osburn, '01.

Notropis cornutus (Mitchill). COMMON SHINER, REDFIN, COMMON SILVER-SIDE, DACE, ROUGH-HEAD, HORNY-HEAD. The Common Shiner (Fig. 187) is poorly represented in Oneida Lake, but is common in streams nearby where conditions are favorable for its existence, judging from our collections (including Nos. 413, 425, 447, 460, 593) made in such places. Fishermen who use "creek minnows" for bait know this fish as the "Shiner" and are familiar with its attractiveness to game fish. It has a rather deep body and bright silvery sides. In these respects it is like the Silverfin, but differs from it in being more robust and in having a larger head and mouth; and the exposed parts of the lateral scales decidedly deeper than long.

Breeding Habits and Life History. This fish appears to breed entirely in streams, in spring and early summer. Hankinson ('08, p. 206) found them spawning in June, in the outlet of Walnut Lake, Michigan. Reighard ('15, p. 228) says that according to his observations the species breeds only in running water on gravel bottom. Forbes and Richardson ('09, p. 148) give May and June as the spawning time in Illinois. Tracy ('10, p. 68) states that it spawns in the spring and early summer in Rhode Island, while Kendall and Goldsborough ('08, p. 31), with reference to the Connecticut Lakes, say, "Its breeding time is in the spring or early summer according to the temperature of the water. At this time the male assumes a beautiful coloration, the fins broadly margined with bright red, the back an iridescent blue, and the sides reflecting all the hues of the rainbow. A more beautiful minnow can scarcely be conceived. The head of the male at this time bears conical, horny tubercles or excrescences, whence the names 'horny-head' and 'buckfish.' The spawning process is interesting. A small school assembles on a fine gravelly shoal where the water runs swiftly but smoothly just above a riffle. A hollow is formed in the gravel, where the eggs are deposited, to be fertilized by the male or males in attendance. In the one instance observed there was only one male present." Greeley ('27, p. 59) mentions a single male with several spawning females. The nest was a depression a foot in diameter and two inches deep, with stones "the size of a hickory nut and an occasional stone the size of an egg." The data were obtained by Dr. G. C. Embury and W. J. Hamilton, Jr.

Fowler ('09, p. 540) writes: "The redfin has an interesting habit of resorting to clear shallows in the spawning season, which occurs about Philadelphia from late April to early summer. Schools of probably several hundred of the brilliantly colored males may be found, closely packed together as a mass of crimson and purple in these places. The females did not seem to take part in these gatherings, or at least I was unable to identify any in the several schools captured. From this it appears that they precede the males to the spawning grounds. Sometimes the males are herded in clear riffles, but usually where there is a sandy or clear, pebble bottom. The females, besides being paler in color, lack the tubercles usually." Hankinson ('20, p. 8) noted the spawning activities of this species in the Galien River, June 3, 1919. A large male would maintain a certain position over a pile of cleaned stones which was being piled up by a Horned Dace. Now and then he would swim out into a school of females and forcibly apply the side of his body to the side of one of these smaller and less gaudy individuals, holding the contact for but an instant. The spawning act was very similar to that found by Reighard in the Horned Dace (Reighard, '10, p. 1131). Two large males in breeding colors (No. 460) were caught by us in Black Creek at Cleveland, on Oneida Lake, June 27, 1916.

Habitat. The Shiner is a stream fish and it was not surprising that we found few in Oneida Lake. It prefers pools in clear, rapid streams, and usually these did not occur near the mouths of creeks, where we did most of our netting. At North Bay, however, we explored a stream for a little distance, and found pools where these shiners were common. We took eleven specimens (No. 593).

Our best lake collections were made in July, 1916, near Sylvan Beach (No. 591, 13 fish) and Lewis Point (No. 501, 7 fish). Both these places had similar conditions—hard, sandy bottom along an open, exposed shore, with little vegetation except marginal zones or patches of rushes or sedges. Small collections of these Shiners were taken at or near the mouths of creeks tributary to Chittenango Creek (No. 546); Dakin Bay (No. 425); Cleveland Bay (No. 460); and East Potter Bay (Nos. 447, 458, 463). Eleven were caught in the swift turbid waters of Douglas Creek (No. 413).

Forbes and Richardson ('09, p. 148) consider it a minnow of streams and smaller rivers, preferring clear water and a clean bottom. Fowler ('09, p. 541) says it is frequently found in rock pools about cascades, and seems perfectly at home in turbulent foamy water. Reighard ('15, p. 228) found it abundant and widely distributed in Douglas Lake, Michigan, and considers this distribution unusual. Cope ('69, p. 373) says that it prefers clear waters and does not haunt rapids.

Food. Twenty-one specimens examined by Forbes (Forbes and Richardson, '09, p. 148; and Forbes, '83, p. 129) had eaten vegetable matter, chiefly algae, which constituted about a third of the food; the rest was chiefly insects, both terrestrial and aquatic, the latter largely predominant, and among these were gyrid larvae and corixid nymphs. A single aquatic worm, *Lumbriculus*, and a few crustaceans were taken by them. One Shiner had eaten only fishes. Reighard ('15, p. 227) found one specimen containing about two-thirds Cladocera, and one-third insects, apparently larval. Two others had eaten some material similar to this, along with bryozoans, (*Gloietrichia*), leaves, and some undeterminable material. Ellis ('14, p. 53) says its food consists of surface and other aquatic insects and some plant materials, other types of food being utilized occasionally. Smallwood ('18, p. 333) found *Daphnia* and insects including honey bees in the stomachs of this shiner taken in the Adirondacks.

Leonard ('27, p. 41) concludes from the examination of the food of six Common Shiners that insects form the most important item of the food of this fish. He found immature stages of May-flies, chironomids (in important amounts), entomostracans, hydrachnids, protozoans, filamentous algae, diatoms, and small terrestrial insects (aphids and psocids). Breder and Crawford ('22, pp. 302, 303) give the results of studies of the food of 265 Common Shiners taken from Oxon Creek of the Potomac System. Important food materials were as follows: insects 57%, largely indeterminable, but nymphs or larvae of Ephemera, Odonata, Plecoptera, Coleoptera, and Diptera were recognized, and there were adults of Hymenoptera and Coleoptera. No correlation between size of fish and nature of the food was found in studies of food of fish that were from 4/5 of an inch to 4 inches in length. Aquarium observation showed that these shiners fed rather promiscuously at all levels above the bottom, as well as on the bottom, and took food from the surface "with both the force and grace of a trout." Greeley ('27, p. 59) found one fish 4 3/8 inches long, from Fulmer Valley, Allegany County, N. Y., to have eaten algae and diatoms (85%), and insects including caddice worms (15%).

Distribution Records. Besides the collections made near Sylvan Beach (No. 591) and Lewis Point (No. 501), only three other collections including this species were obtained from the lake. These were taken at Brewerton (No. 305, one fish, October 5, 1915); Lakeport Bay (No. 416, one fish, June 22, 1916) and Fairchild Bay (No. 483, one fish, June 30, 1916). The following are stream records, and in each case the fish were caught within a quarter of a mile of the stream mouth at Oneida Lake; No. 413, Douglas Creek, 11 small fish; No. 425, creek at Dakins Bay, 9 small fish; No. 460, creek at Cleveland, 2 large breeding males; Nos. 447, 458, 463, creek at East Potter Bay; and No. 593, creek at North Bay, 11 small fish. In a small, short tributary of Chittenango Creek, one was taken (No. 546).

Enemies and Disease. Fowler ('13) found Common Shiners in stomachs of Dabchick, (*Podilymbus podiceps*), Green Heron, (*Butorides virescens*), and Kingfisher, (*Ceryle alcyon*). Audubon (l.c., p. 13) saw a Bald Eagle (*Haliaeetus leucocephalus*) secure a number of these fish by wading and striking them with its bill. Bones of this fish have been found in a Kingfisher's nest (Fowler, '14, p. 349). Linton ('97, pp. 423, 438) found the species infested with a cestode parasite (*Dibothrium ligula*). This parasite was in a male fish 4 inches long caught at Fulton Chain, Adirondacks. In our collections from creeks tributary to Oneida Lake we found some diseased fish (Nos. 413, 447, 593). Many large specimens (Nos. 1509, 1519) of this species from North Pond, Boonville, N. Y., collected by H. A. Malcolm, in September and October, 1916, appear to be generally infested with large cestodes (*Ligula* sp.), some of which were removed and found to be three to four inches long; one at least was as long as its host. Osburn ('01, p. 10) tells of a Myxosporid parasite attacking this minnow. LaRue ('26, p. 285; and Butler, '19, p. 116) record larval trematodes in the eyes of this species found in Douglas Lake, Michigan.

Economics. The Shiner is famous as a bait minnow. Evermann ('01, p. 326) thinks that on the whole it is the most important of all bait minnows; doubtless more of this species are used, and more fish caught with it than with any other minnow. Henshall ('17, p. 268) says: "The Shiner is, by all odds, the best bait for the Black Bass, being quite silvery, as its name implies, and shows well in the water. It is not so hardy, or long-lived on the hook, as the chub or steel back; but on account of its white and silvery appearance it is especially desirable for turbid or rough water, and on cloudy or dark days, though it is, for that matter, a good bait at all times." Fowler ('08, p. 541) considers it excellent as bait. Reighard ('15, p. 228) considers it important, on this account, to locate and preserve its breeding grounds. Kendall ('18, p. 517) says it is one of the best live baits.

As a food fish it is practically useless on account of its small size. It is not adaptable to the ordinary aquarium for it does not thrive.

References. Bean, '03; Butler, '19; Cope, '69; Ellis, '14; Evermann, '01; Forbes, '83; Forbes and Richardson, '09; Fowler, '08, '09, '13, '14; Greeley, '27; Hankinson, '08, '20; Henshall, '17; Kendall, '18; Kendall and Goldsborough, '08; LaRue and others, '26; Leonard, '27; Linton, '97; Mather, '86; Osburn, '01; Reighard, '15; Tracy, '10; Wilson, '02; Wright and Allen, '13.

Exoglossum maxillingua (LeSueur). CUT-LIP MINNOW, CUT-LIPS. The Cut-lips was found in streams connected with Oneida Lake, and in small numbers in the lake itself near the creek mouths. It is easily distinguishable from other fish by its peculiar lower jaw, which is divided into three distinct lobes, with the two dentary bones lying parallel, united, and stiffening the central lobe, making it apparently an effective instrument for dislodging snails and other edible objects from surfaces of stones.

Breeding. Hankinson ('21, pp. 1-3) found this fish building its nest in Butter-nut Creek, near Jamesville, New York. The creek is a tributary of Chittenango Creek and hence lies in the Oneida Lake drainage basin. A large and unusually dark colored male was carrying small stones and piling them just as the Fallfish and some other minnows do. This was on May 8, 1921, and the nest was evidently completed the next day. It was then a flat pile about eighteen inches in diameter and built of angular and rough stones (a feature that enabled the fish to grasp them with its small mouth), much smaller in size than stones in any of the Fallfish nests he had ever seen. Their longest diameter was usually about a half inch. Eggs could not be found and spawning was not noted, but an apparent attempt was made by the working male to herd females at the stone pile. Greeley ('27, p. 60) found a nest of Cut-lips on June 23, 1926, in the Genesee River. His observations on construction of the nest were similar to those of Hankinson, but he found eggs in the nest, adhering to the gravel.

Habitat. This fish seems to be distinctly one of clear running streams (Bean, '03, p. 164; Fowler, '09, p. 52), and Hankinson and others (Reed and Wright, '09, p. 396; and Bean, '03, p. 164) have found them common in creeks at Ithaca, N. Y., where favorable conditions prevailed. Jordan ('82, p. 841) notes that it prefers clear rock pools but does not haunt rapids. Cope ('69, p. 360) says of the Cut-lips: "In its movements it is sluggish; it keeps near the bottom in pools and channels of our clear rocky streams, not preferring rapids."

At Oneida Lake they were found numerous (Nos. 75, 76, 142) only in Scriba and Frederick Creeks, August 31, 1915, in places where the bottom was rocky and the water clear and rapid. In Black Creek and Douglas Creek, where we made large collections of other fish from rocky bottoms and swift water, none was taken, which may have been due to roily water at the times we worked. That these fish are driven to the lake by such conditions is indicated by the fact that the few Cut-lips caught in the lake in 1916 were taken in June, when the tributary streams were turbid. But much more information is needed before such a change of habitat can be ascribed to them with certainty.

Food. Bean ('92, p. 37; '03, p. 164) says that the singular mouth structure is thought to enable the fish to scrape mollusks from their hold on rocks, as its stomach usually contains small shellfish; he also mentions that it takes the hook readily. Gill ('07, p. 312) says that mollusks form the principal food of this fish, and that ordinarily crushed shells may be found in its stomach.

Jordan ('82, p. 841) quotes Professor Cope as saying: "Its stomach usually contains abundant remains of *Physa*, *Pisidia* and other small Mollusca, which form its food."

Breder and Crawford ('22, p. 306; 307) give results of the examination of the food of 59 of these minnows. Insects (Coleoptera and unidentifiable parts)

made up 35% ; chaetopod worms, 30% ; diatoms, 8% ; unidentifiable material, the remainder. The fish were from Oxon Run, a tributary of the Potomac. Greeley ('27, p. 61) found three midge larvae and the claw of a small crawfish in a three inch Cut-lips.

Distribution Records. Nos. 75, 76 and 142 were from Scriba and Frederick Creeks and contained in all 29 specimens. One, No. 88, was from Chittenango Creek; and five, No. 90, from Maple Bay, not far from the mouth of this stream. All of the above were taken from August 31 to September 8, 1915. In the summer of 1916, we got but five examples of this species, which were in three lake collections: No. 400, Froher Bay; No. 422, Mathews Point; No. 427, Dakin Bay.

Economic Relations. Bean ('92, p. 37; '03, p. 164) says that it grows to a length of six inches and takes the hook readily—therefore highly prized by boys—and that it is a good pan-fish. Evermann ('01, p. 336) states that it is of some value as a bait minnow. He has seen it thus used at various places on the St. Lawrence, and says it lives well and is an active fish, but rather dull in color.

References. Bean, '92, '03; Breder and Crawford, '22; Evermann, '01; Fowler, '09; Gill, '07; Greeley, '27; Jordan and Evermann, '96; Meek, '89; Reed and Wright, '09; Wright and Allen, '13; McAtee and Weed, '15; Jordan, '82.

Notemigonus crysoleucas (Mitchill). GOLDEN SHINER, ROACH, BREAM. This is the common large flat shiner so frequently taken on the hook while fishing for perch or sunfish. Small individuals are caught together with bait minnows in small seines used in shallow waters. The species is easily distinguished by its flat, nearly elliptical body, small mouth, fine scales which are easily removed, long anal fin and sharp ventral edge of the body in front of this fin. Although it is edible, it is commonly considered of little value.

Breeding Habits and Life History. The eggs are adhesive and are laid on plants in quiet waters, from May to July 1, according to Wright and Allen ('13, p. 4). Breeding males have the lower fins scarlet (Bean, '03, p. 134), and are smaller than the females; the back is more swollen at the nape, and the sides of the body are rough with minute tubercles (Forbes and Richardson, '09, p. 128). Embury ('15, p. 227) gives notes on the growth of this species as follows: 5 months, average length 1½ inches; 1 year, 2 inches; 2 years, 2½ to 3 inches. Allen ('14, p. 57) mentions a migration and says it begins to run in April at Ithaca, N. Y., but does not begin to spawn until the latter part of May. Hubbs ('21a, p. 147), in discussing the variation of this species, gives a few notes on its life history. He says that it may reach a length of a foot and a weight of 1½ pounds, but in small ponds it is more or less dwarfed, breeding at an age of one or two years.

Habitat. Golden Shiners are usually confined to areas having thick growths of aquatic plants, and were abundant in such places in Oneida Lake. Often large schools of them could be seen moving among the pond weeds and water lilies; and when the trammel net was set about such places, and about rush and cat-tail patches, large hauls were usually taken (Nos. 76, 102, 470, 485, 489, 504, 505, 528, 542, 561, 600). Many of the large fish, however, usually 8–9 inches long, were out in the lake, where plants were not especially numerous, in water 5 to 12 or more feet deep. Gill nets in such places usually brought a few of these fish, and



Fig. 207. Shrub, rush and *Castalia* zones in Fairchild Bay. July 26, 1916.



Fig. 208. Shrub bordered shore of Fairchild Bay. June 30, 1916.



Fig. 209. Cobble shore of Dunham's Island. July 10, 1916.



Fig. 210. Cobble beach of Frenchman's Island. July 11, 1916.

on one occasion, July 20, 1916, seventy (No. 583) were caught in a gill net set at the west end of Dunham's Island, in a channel without evident vegetation, and where the water averaged about ten feet in depth. Golden Shiners were very numerous here and no other fish were found with them. We found many small fish of this species in the streams at Constantia (No. 75), in Chittenango Creek and in one of its tributaries (No. 87).

In other localities the fish appears to be closely confined to the sluggish waters of streams, bayous, ponds, and lakes, and is sometimes abundant "in the muddiest and most uninviting holes" (Forbes and Richardson, '09, p. 126). Abbott says of its habitat (Nelson, '90, p. 681): "The roach is everywhere met with in New Jersey, preferring still waters, with an excessive growth of vegetation upon the bottom of the stream. In these masses of vegetation it conceals itself from attacks of the pike, which latter feed almost exclusively upon them." Cope ('69, p. 390), in writing of the fish in Pennsylvania waters, says that in rapid rivulets it is rarely seen of large size, and that it seeks the cut-offs and ditches. Schultz ('26, p. 418) notes that the species has a marked adaptability to temperature differences, since it lives in cool trout streams of the north and in warm lakes of the south.

Food. Forbes and Richardson ('09, p. 127) found the food differing widely in the twenty-five specimens examined from different parts of Illinois, consisting of mollusks, insects (mainly terrestrial), entomostracans, algae, and mud. Baker ('16, p. 171) examined eighteen specimens from Oneida Lake and found 97% of the food to be insects, with caddis-fly larvae predominating; some mollusks were in one fish. Eight specimens contained no food. Hankinson ('08, p. 205) found midge larvae and filamentous green algae to be the principal material eaten by Walnut Lake specimens. Embury ('15, p. 242) notes that the species feeds upon filamentous algae. Kendall ('18, p. 518) says the fish subsists mainly upon insects and entomostracans. Seal ('10, p. 836) considers it to be an active destroyer of mosquitoes.

Dr. J. Percy Moore ('22, pp. 11-12) examined the contents of the enterons of 66 young and a few adults of this species. Algae, entomostracans and miscellaneous insect material predominated in the food material. Adult mosquitoes appeared to be taken in unimportant numbers. Emmeline Moore ('22, p. 53) tabulates the results of stomach examinations of 23 Golden Shiners from Lake George, N. Y. The fish were $\frac{3}{4}$ to $4\frac{1}{2}$ inches long. Insects, plankton, crustaceans, protozoans, filamentous algae and diatoms were important food objects. Greeley ('27, p. 59) makes note of the food of three very small fish ($\frac{9}{16}$ of an inch long) in which algae (*Spirogyra*) composed 95% of the intestinal contents; the rest was the remains of a water mite. Pearse ('18, p. 252) gives results of the examinations of 59 of these fish from lakes near Madison, Wisconsin. They were from 1 to 6 inches long. The food percentages are as follows: insect larvae, 4.4%; adult insects, 2.2%; insect pupae, 5.7%; entomostracans, 76.1%; amphipods, 2.2%; mites, .4%; rotifers and protozoans, 1%; algae, 1.5%; other plant material, 3.1%.

Distribution Records. The following collections were made in shallow lake water from August 31 to September 7, 1915: No. 76, Constantia; No. 86, Paddy-gut Bay; No. 90, Maple Bay; No. 100, Walnut Point; No. 102, Ladd Point; No. 105, Muskrat Bay; Nos. 120, 121, Big Bay Shoal. At this time the following

creek collections were also made: No. 75, Scriba Creek; No. 81, Johnson's Bay Creek; Nos. 116, 118, Big Bay Creek.

In June and July, 1916, the following collections were made in shallow water: No. 403, Shackelton Point; No. 427, Dakin Bay; No. 441, Taft Bay; No. 470, Cleveland Bay; No. 475, Lower South Bay; No. 485, Fairchild Bay; Nos. 489 and 490, Three Mile Bay; Nos. 504, 505, Upper South Bay; No. 517, Sylvan Beach; Nos. 526, 528, Maple Bay; No. 542, Johnson's Bay; Nos. 573, 597, Norcross Point; No. 577, Three Mile Bay; No. 600, Milton Point; No. 604, Wedgeworth Point. In the deep water of the lake we also took some Golden Shiners at this time: No. 519, in twelve feet, off Norcross Point, one large fish; No. 583, in about ten feet, off Dunham's Island, 74 large fish.

In streams, in June and July, 1916, two collections containing Golden Shiners were made: No. 513, Oneida Creek; No. 590, Chittenango Creek.

Three fall collections made in October and November contained this species: No. 5, Lower South Bay; Nos. 314, 624, Brewerton. Also at Sylvan Beach, Sept. 9, 1927, the fish was taken (No. 4272).

Enemies and Disease. No doubt these shiners are eaten extensively by the larger predacious fish of the lake. Remains of this species were found in stomachs of two Chain Pickerel caught at Fairchild Bay, June 30, 1916. (See p. 393.) Their abundance in the deeper water would make them especially available to predatory species. Fowler ('13) found that Golden Shiners were eaten by Pied-billed Grebes (*Podilymbus podiceps*), Mergansers (*Mergus americanus*), Bitterns (*Botaurus lentiginosus*), Green Herons (*Butorides virescens*), Night Herons (*Nycticorax nycticorax naevius*), Greater Yellow-legs (*Totanus melanoleucus*), Fish Hawks (*Pandion haliaetus carolinensis*), Kingfishers (*Ceryle alcyon*), and Crows (*Corvus brachyrhynchos*). Fowler ('14, p. 349) notes finding bones of this species in a Kingfisher's nest. Abbott ('74, p. 330) says it is a favorite prey of kingfishers due to its odor [flavor?]. Nichols ('15, p. 28) found 90 pharyngeal bones of the Golden Shiner in a recently occupied nest of kingfishers and suspects that the bird discriminates in favor of this species. Diseased Golden Shiners were common in Oneida Lake. Water-mold, probably *Saprolegnia*, had attacked many of them, and frequently fish could be seen swimming with large masses of it on their bodies; and many that were caught were thus infested (Nos. 427, 517, 583, 600). In one collection (No. 517) thirty-one were parasitized, giving them a black-speckled appearance, due probably to trematode worms. In a large collection of 74 Golden Shiners (No. 583) from Dunham's Island, many of the fish had small leeches upon their fins (No. 584). VanCleave ('23, p. 82) records the acanthocephalan, *Pomphorhynchus bulbocolli* Linkins, in a Golden Shiner from Oneida Lake.

At Otisco Lake, southwest of Syracuse, forty Golden Shiners (No. 1521) were caught on July 16 and 17, 1917, by A. G. Whitney; all of these, with perhaps one exception, were diseased, the external portions of the body being whitish, translucent and ulcerous in a few cases. Many had portions of the fins missing and body wounds, suggesting that their diseased condition made them subject to the attacks of certain enemies, perhaps turtles. Kendall ('18, p. 518) notes that the species contributes largely to the food supply of pickerel, in Umbagog Lake, Maine. Allen ('14, p. 57), in writing of the fish near Ithaca, N. Y., says that it provides the chief forage for the larger predacious fishes and for the Kingfisher.

Economics and Angling. If these fish feed extensively on insects, as they appear to do (Baker, '16, p. 171), they may compete with the more desirable sun-fish, perch, and other species in Oneida Lake that eat insects. To what extent this is counterbalanced by the shiners becoming food for better fishes is not known. There is a diversity of opinion as to the palatability of Golden Shiners, and perhaps they differ in this respect in different regions. Hankinson has found large ones to be fair table fish. Forbes and Richardson ('09, p. 127) mention it as "an excellent pan-fish." It is shipped by dealers from Oneida Lake to New York City as cull fish. Nash ('08, p. 39) says it is soft and weed flavored. Its small size and lack of gameness certainly do not make it a favorite with anglers, except as bait. According to Cheney ('98, p. 243), it is excellent for lake trout fishing, and he paid as much as a dollar for two Golden Shiners for this purpose. He says that they are used as bait for black bass in summer, but are not considered as good for this purpose as others of the *Cyprinidae*. Its silvery sides make it attractive as a bait, but it lacks hardness on the hook and its scales are lost easily. Forbes and Richardson ('09, p. 127) consider it a good bait for black bass.

In stagnant waters the Golden Shiner is a valuable mosquito destroyer. Smith ('04, p. 106) says that wherever it occurs mosquito larvae are absent. Experimentally this was made convincing by introducing a specimen into a barrel swarming with wrigglers, where in a couple of days it had devoured practically all of the larvae. It was then transferred to another barrel where its work was equally thorough, although a little slower. Against *Culex* this species is excellent, but against *Anopheles* and some other species that favor grassy areas it is less important. Seal ('10) seems to consider it the only fresh-water minnow worthy of attention in this connection. Moore's results ('22, p. 14) make it appear that this fish has been much overrated as a mosquito destroyer. In Oneida Lake the species constitutes a potential and indirect supply of nourishing human food. Embury ('15, p. 237) notes the Golden Shiner to be an important pond fish as food for other fish, fully meeting the four requirements of a "forage fish" of a pond in that (1) it spawns in the pond; (2) its food consists largely of vegetation; (3) it is relished by fishes desirable for propagation; and (4) it does not grow so rapidly the first years as to make it too large to be eaten by other fishes. Kendall ('18, p. 518) considers it an excellent bait fish in Maine.

References. Abbott, '74; Allen, '14; Baker, '16; Bean, '03; Cheney, '98; DeKay, '42; Embury, '15; Evermann, '01; Forbes, '83; Forbes and Richardson, '09; Fowler, '09, '13, '14; Greeley, '27; Hankinson, '08; Moore, E., '22; Moore, J. P., '22; Nash, '08; Nelson, '90; Nichols, '15; Schultz, '26; Seal, '10; Smith, '04; Tracy, '10; Wright and Allen, '13.

Hybognathus regius Girard. SILVERY MINNOW. This is a common minnow in the lake, often found with other species along the shore. The form called "smelt" or "gudgeon," identical with this species, is common near the mouth of the Delaware and perhaps in other rivers on the coast, and becomes large enough for the pan, sometimes nine inches in length (Fowler, '09, p. 522). None more than four inches long were caught by us in Oneida Lake.

Breeding. In July, 1916, we found schools of small Silvery Minnows at Poddygut Bay (Nos. 569, 605) and Three Mile Bay (No. 577). Since these fish

were about of a size, near an inch long, and most of the others taken were decidedly larger it is likely that they were yearlings, and that the eggs were probably laid in the spring. No specimen with pearl organs or other external evidences of breeding condition were taken by us. Bean ('03, p. 118) says this fish spawns in early spring.

Habitat. The species appeared to be quite generally distributed in shallow water during the summers when most of our collecting was done, but it was common in only a few places. These were Paddygut Bay, Fairchild Bay, Shaw's Bay, Lower South Bay, Three Mile Bay, Bernhard's Bay, Messenger Bay, Sylvan Beach, and the creeks at Johnson's Bay and at Constantia. The small fish very evidently preferred areas with much vegetation and were usually found over a bottom having much humus. The larger ones were frequent both in such situations and over sandy bottoms with little plant life.

Distribution Records. Nos. 305, 314, 353, 622, Brewerton; Nos. 116, 120, 121, 569, Big Bay; No. 86, Paddygut Bay; Nos. 483, 603, 604, Fairchild's Bay; No. 605, Shaw's Bay; No. 577, Three Mile Bay; No. 77, Bullhead Bay; No. 90, Maple Bay; No. 453, Bernhard Bay; No. 463, Potter Bay; No. 577, Sylvan Beach; No. 501, Lewis Point; No. 498, Messenger Bay; No. 90, Maple Bay; No. 611, Lower South Bay; No. 522, Frenchman's Island; No. 529, Dunham's Island; Nos. 75 and 76, Scriba Creek; Nos. 4270 and 4272, Sylvan Beach, September 9, 1927.

Enemies and Disease. Fowler ('13, pp. 8-9) tells of two birds feeding upon *H. nuchalis regius*, namely, the Loon (*Gavia immer*) and the common Tern (*Sterna hirundo*).

Economics. Bean ('03, p. 118): "It is extensively used for food along with the *Notropis hudsonius*, the so-called 'smelt' or 'gudgeon.' It takes the hook very freely during the spawning season." It is not a very good bait-minnow as it is not hardy (Forbes and Richardson, '09, p. 115, and Ellis, '14, p. 44). Smith ('07, p. 86), however, says it is a desirable bait for black bass and perch.

References. Bean, '03; Fowler, '08, '09, '13; Smith, '07.

Hyborhynchus notatus (Rafinesque). BLUNT-NOSED MINNOW, BULLHEAD MINNOW, FAT-HEAD CHUB. This is a common minnow locally known as "Chub" and frequently taken in the lake to be used as bait, but probably not often distinguished from the other kinds of minnows so used. It may be distinguished readily from other Oneida Lake fishes by the following features: size small, usually less than three inches in length and seldom as long as four inches; scales on the back conspicuously finer than those on the rest of the body; a black spot at the base of the dorsal fin in front, and one at the base of the caudal fin.

Breeding Habits and Life History. Eggs of Blunt-nosed Minnows are ordinarily placed on flat lower surfaces of properly situated stones; and the male fish remains beneath, guarding them. This attending male has the body highly pigmented and often appears black, and on his snout are conspicuous tubercles or pearl organs. He is very bold, and if the stone be removed, he moves slowly about in the vicinity and may be easily captured. We found eggs but once (No. 530) in Oneida Lake, and these were on the under side of a small water-logged piece of board on a small area of sandy bottom, in two feet of water, off Dunham's Island. They were attended by a male three inches long, which was busy keeping away a Tessellated Darter. The darter and the minnow were both collected (No. 530).

We found no eggs under stones in the lake although much search was made for them. But few suitable stones occurred, most of them being usually so firmly imbedded in the soil that no cavities existed beneath them in the shallow water where the minnows generally breed. This condition may be due partly to pressure of ice in winter and may be the reason why Blunt-nosed Minnows are not more numerous in the lake.

The spawning season for this species appears to be rather long and late. Wright and Allen ('13, p. 4) give it as May 15 to July 15, for Ithaca, N. Y. Hankinson ('08, p. 205) found nests between May 22 and July 14, at Walnut Lake, Michigan. Forbes and Richardson ('09, p. 121) give May 15 to June 15 as dates for Central Illinois. Eigenmann ('96, p. 252) found eggs during the whole of June and the greater part of July. Evermann and Clark ('20, p. 344) say the breeding season of this minnow is early in June, and they found nests under small pieces of board or other flat objects lying on the bottom. Some evidence of a late breeding season in Oneida Lake is presented by the fact that we found examples about an inch in length, apparently yearlings of this species, common only in late summer, on the following dates: July 27, 1916 (No. 610), September 2 (No. 90) and September 15 (No. 87), 1915. Brief notes on the breeding of this species are given by Reighard ('15, p. 226), Voris ('99, p. 233) and Fowler ('12, p. 472). Greeley ('27, p. 58) found eggs on the lower side of an old milk can top, in shallow water.

Habitat. Most of the large collections of Blunt-nosed Minnows taken by us were from shallow water over or near sandy bottom (Nos. 83, 90, 422, 463, 501, 522, 523, 585, 610). They were common in two streams, a tributary of Chittenango Creek (No. 87), and Douglas Creek (No. 413). On June 22, 1916, they were numerous in very shallow water over a sod bottom on flooded ground at Lakeport Bay.

Its habitat appears to be of diverse nature, according to Forbes and Richardson ('09, p. 120); Bean ('92, p. 36) says it frequents small and muddy streams; Hankinson ('08, p. 204) found it to prefer gravel bottoms, in Walnut Lake. They appear to live more over sand and gravel than over mud, according to Forbes ('09, p. 428). Reighard ('15, p. 226) found them preferring stony shoals or mucky bottom; the latter furnished food and the former breeding places. Reighard ('20, p. 2) notes that they are exceptional among the minnows he has studied, in that they breed in quiet water. Evermann and Clark ('20, p. 285) note a shoreward migration of these minnows together with that of other species.

Food. Forbes ('83, p. 125) and Forbes and Richardson ('09, p. 121) found them eating chiefly mud, with filamentous algae and miscellaneous vegetable debris; but Hankinson ('08, p. 204) reports that midges formed their chief food in April and May in Walnut Lake, Michigan, and they were taking in addition filamentous algae, desmids, entomostracans, and in one case, beetles. They fed on eggs of other fish and were once observed eating newly hatched young of their own species. Reighard ('15, p. 226) considers this minnow a "mud eater."

The food of sixteen Blunt-nosed Minnows was examined by Dr. Emmeline Moore ('20, p. 18). Daphnids, chironomid larvae, rotifers, statoblasts, insect remains, microscopic plants and grit were found in their intestines. Evermann and

Clark ('20, p. 295) found insect remains together with *Bosmina* and *Cyclops*, in five specimens.

Greeley ('27, p. 58) found diatoms and filaments of algae in one fish examined from the Genesee River. Pearse ('18, p. 271) studied the food of sixty specimens ranging from 1 to 3 inches, taken in Wisconsin Lakes. The findings are summarized as follows: insect larvae, 14.5%; insect pupae, 5.8%; adult insects, 4.5%; entomostracans, 28%; oligochaete worms, 7%; algae, 19.3%; other plant material, .9%; silt and debris, 20%.

Distribution Records. From the shallow water of Oneida Lake we took the following collections containing this species: No. 5, Lower South Bay; No. 76, mouth of Scriba Creek; No. 83, Johnson's Bay; No. 86, Paddygut Bay; No. 105, Muskrat Bay; No. 120, Big Bay; No. 124, Fairchild Bay; No. 309, Lower South Bay; Nos. 314, 353, Brewerton; No. 401, Billington Bay; Nos. 403, 408, Shackleton Point; No. 418, Lakeport Bay; Nos. 419 and 422, Mathews Point; No. 427, Dakin Bay; No. 441, Taft Bay; No. 447, East Potter Bay; No. 453, Bernhard Bay; No. 456, West Potter Bay; Nos. 459, 463, East Potter Bay; No. 483, Fairchild Bay; No. 491, Three Mile Bay; No. 505, Upper South Bay; No. 522, Frenchman's Island; No. 523, Shortpoint Bay; No. 526, Maple Bay; Nos. 529, 530, 539, Dunham Island; No. 543, Frenchman's Island; No. 550, Godfrey Point; No. 585, Lower South Bay; No. 599, Brewerton; Nos. 610 and 611 Lower South Bay.

The stream collections are: No. 75, Scriba Creek; No. 87, tributary of Chittenango Creek at the Protector's camp; Nos. 88, 89, 90, Chittenango Creek; No. 413, Douglas Creek.

Enemies and Disease. Predacious fishes undoubtedly feed on Blunt-nosed Minnows, just as they do on other species. Their eggs are evidently sought by other small fishes, since the male that watches them is frequently observed driving intruders away. A Johnny Darter, as previously mentioned, was seen disturbing one of these minnows in Oneida Lake. Kingfishers also are known to feed on them (Fowler, '13, p. 15).

Nine diseased specimens were taken by us from Oneida Lake (Nos. 401, 413, 416, 418, 422, 441, 447, 522). One of these collections (No. 441) contains two specimens, one with abdomen much swollen, and one with large wart-like swellings on the body.

Economics and Angling. While no direct observations were made on the taking of these minnows by larger fishes, there can be no doubt that they are thus preyed upon. Black bass, Pike Perch, Pickerel, and Burbot, all of which are common in Oneida Lake, feed extensively on other fishes (Forbes, '88, p. 478); and minnows, in the words of Forbes (l.c., p. 480), "are in our waters especially appropriated to the support of half-grown game-fishes, and the smaller carnivorous species." So far as we know there is little discrimination on the part of fishes in feeding on minnows, and Blunt-nosed Minnows are probably taken in the proportion in which they are found on the feeding grounds of the predacious forms. Besides the distinctly piscivorous fishes mentioned, others which are common in Oneida Lake undoubtedly eat minnows to some extent. These are Perch, Rock Bass, Calico Bass, Bullheads and Eels.

If the food of Blunt-nosed Minnows were to be studied and compared with that of other fishes in Oneida Lake it is likely that these minnows would be found to compete with some of the others, as they do in Walnut Lake (Hankinson, '08, p. 204). They probably eat eggs of some fishes, including those of black bass and sunfish, as they were found to do in Walnut Lake (l.c., p. 204), and in this way they may be positively destructive to food fishes. Fishermen consider it to be a good bait minnow in Oneida Lake, for it lives well on the hook, and large ones are attractive to Perch. Evermann ('01, p. 315) says it is the best and most important bait minnow obtained from Lake Maxinkuckee, Indiana.

References. Eigenmann, '96; Evermann, '01; Forbes, '83, '88, '09; Forbes and Richardson, '09; Fowler, '12, '13; Greeley, '27; Hankinson, '08; Moore, '20; Pearse, '18; Reighard, '15, '20; Voris, '99; Wright and Allen, '13.

Ictalurus punctatus Rafinesque. SPOTTED CATFISH, CHANNEL CAT. (See Figure 200.) This is primarily a fish of large swift and clear streams. An effort should be made to propagate this species in Chittenango Creek and Oneida River, as it is one of the best inland food fishes. It is readily distinguished from other Oneida Lake Catfish by its forked tail and the small round spots over the sides of its body. A single market specimen is all we have obtained of this catfish from Oneida Lake.

Breeding Habits and Life History. The spawning season, according to Forbes and Richardson ('09, p. 183), is in May, but it is reported by Jordan to begin spawning in June.

Surber ('20, p. 16) says it spawns in very swift water, sometime during the early spring, or not later than July 1st.

Dyche ('14, p. 78) notes that while the spawning habits of the Channel Cat are not well understood, it is generally believed among fish culturists that the eggs will not hatch except in currents and channels of moving water.

Jones ('84, p. 321) asserts that the "Speckled Catfish" (which Kendall assumes to be *punctatus*, although as Shira '17, p. 78, has suggested, there is some reason to doubt this identity) spawns when a year old, in May and again in September, and cares for its young. If this double season is true it is the only Oneida Lake species that has two breeding seasons; and it suggests a long breeding period interrupted by the warm weather. Jones' observations were made in Georgia, where perhaps the season is not interrupted as it is in the northern part of its range. It is unusual for a fish to spawn in both warming and cooling water. Ellis ('14, p. 18) records the spawning season for Colorado as the "latter part of May, June, and early part of July." Kendall ('10, p. 31) remarks: "Observations as to the spawning habits of this species have proved difficult to make, and are as yet inadequate to afford proper knowledge upon which to proceed." Very recently, however, an important paper by Shira ('17) adds much to our knowledge of the breeding habits and life history of this fish. In a large aquarium at the Bureau of Fisheries, at Washington, observations were also made (l.c., p. 79) showing that on July 9, the female laid about 3,000 eggs in a nest, and that the male cared for the young. The pair refused food and hibernated during the winter. The successful rearing of the young was done in the ponds at Fairport Biological Station on the Mississippi River, where the eggs were deposited in nail-

kegs placed at the margin of the ponds. Eggs and fry were found during the first week in July, and by September the fry were about four inches long. The stomach contents of 72 young examined showed that midge larvae, *Chironomus*, and mayfly nymphs, *Ephemera*, were very large items in their diet. The large proportion (18%) of ooze and debris is worthy of special attention, because this sort of food for young fish may be of more importance than has been generally recognized. (Cf. Baker, '16, on dust-fine detritus.)

Habitat. The habitat of this species is quite different from that of the Bull-head. Hay ('94, p. 181) states that it "delights in clear, flowing rivers and brooks, and the vicinity of water falls." Jordan ('85, p. 34) describes the habitat as follows: "It seems to prefer running waters, and both young and old are most abundant in gravelly shoals and ripples. The other catfishes prefer rather sluggish waters and mud bottoms. I have occasionally taken channel cats in ponds and bayous, but such localities are apparently not their preference. They rarely enter small brooks, unless these are clear and gravelly."

Henshall ('19, p. 245) says that unlike most of the catfishes, this one is found only in clear or swift streams, never in still, muddy situations, and notes (p. 246) that it is fond of deep pools below mill-dams and in the channels of streams off gravelly or rocky shoals, and near shelving banks and rocks.

Food. This, according to Jordan ('85, p. 34), consists of insects, crawfish, worms, and small fishes. Forbes ('88, pp. 456, 459) studied the stomach contents of forty-three specimens (cf. Adams, '92; Forbes and Richardson, '09, p. 182; and Baker, '16, pp. 173-174). About 25% of the food consisted of plant materials; insects formed more than 40%, and mollusks, 15%. This is one of the few species of fish which eat freshwater mussels in large numbers. Mention has already been made of the food of the young (Shira, '17, p. 79).

Moore ('20, p. 18), on examination of fourteen fingerling Channel Cats, found entomostracans and insects as the chief food material. McAtee and Weed ('15, p. 9) found portions of an Eel in the stomach of a Spotted Catfish, while in another 90% of the contents were mayflies (*Hecagenia bilineata*). One stomach was filled with seeds of elm (*Ulmus americanus*). Snails, ants, hellgrammites (*Corydalis*), stoneflies, beetles and vegetable debris made up small percentages of the food. Wilson ('20, p. 226) finds adults eating dragon-fly and damselfly nymphs. Henshall ('19, p. 245) describes it as a clean, wholesome fish that feeds mostly on minnows and crawfish.

Distribution Records. Our only specimen (No. 601) was secured from Coville's market at Brewerton in July, 1915. Previously Coville (Adams and Hankinson, '16, p. 159) had informed us of the presence of a fork-tailed catfish in the Lake. W. H. Weston describes a spotted, forked-tail catfish which he got from Chittenango Creek near the protector's camp. It was taken in June.

On July 9, 1917, we saw a dressed market specimen weighing 2¼ pounds at Coville's market at Brewerton. Mr. W. A. Dence assures us of the presence of this fish in considerable numbers in the Oneida River near Brewerton.

Enemies and Disease. No records have been found of parasitic worms from the Channel Cat. (Wilson, '16, pp. 339, 353, 361, 364) records glochidia of the mussel *Quadrula*, from the gills and fins; and the copepod parasites *Ergasilus*

versicolor Wilson, *Achtheres pimelodi* Kroyer, and *Argulus appendiculosus* Wilson, from the gills or outer surfaces of the body. Of 168 specimens examined for glochidia by Surber ('13, p. 114), none was found infested. Ward ('94, p. 54) mentions a few trematodes and cestodes in fishes from Lake St. Clair but the species were not determined. Howard ('13) found the glochidia of the valuable pearl-button mussel, *Quadrula pustulosa*, infesting this fish, and experimentally proved that it could be infested artificially. Evermann and Clark ('20, Vol. 2, p. 80) notes that *Ergasilus versicolor* Wilson has been obtained from the Channel Cat. Wetmore ('24, p. 20) found remains of *Ictalurus punctatus* in the stomach of a Piedbilled Grebe.

Economic Relations. Jordan ('85) early recognized the importance of this as a food fish. He says: "The skin is thin and translucent, much less thick and leathery than in our common catfishes (*Ameiurus*). The head is small, the mouth small, and the body slender. There is much less waste in the body of the channel cat than in other catfishes, as the latter lose more than half their weight by the removal of the head, the entrails and the skin. . . .

"The flesh of the channel cat, when fresh, is very superior; it is white, crisp, and juicy, tender and of excellent flavor. It is much more delicate both in fiber and in flavor than that of our other catfishes. When well cooked, I consider it superior to that of the black bass, the wall eye, the yellow perch or any other of our percoid fishes. Among our fresh-water fishes, it is inferior only to the white-fish, the trout, and other *Salmonidae*.

"The Channel cat is much less tenacious of life than the 'bull head' (*Ameiurus nebulosus*) and other *Ameiuri*."

"As a food fish, the Channel cat is certainly more worthy of attention than any other American catfish. . . . In the streams of western Europe, which are not cold enough nor clear enough for the trout, the channel cat ought to thrive, and there is no fish native to those waters which is as valuable for food."

Kendall ('04, '10) has published two papers summarizing our knowledge of the economic importance of this and other catfishes. Evidently this is a fish whose merits have been neglected and which deserves greater encouragement from the fish culturists.

An unexpected economic value has recently been discovered in this fish in its acting as a nurse or host for a river mussel valuable in the pearl-button industry, as Howard ('13) has shown. "The results," he says, "would seem to demonstrate *Ictalurus punctatus* as a natural host for *Quadrula pustulosa*, and the experiments so far as they have gone would indicate that other species of catfish may be also. The possibilities offered by the catfish as a medium for artificial propagation are obviously almost ideal. This fish, valuable for food, is abundant and can be transported and handled with less mortality perhaps than any other species. These conditions make the expense of propagation less and the chances of successful distribution in every case greater."

Angling notes. The Channel Cat also ranks high as a game fish. Kendall ('04, p. 405; '10, pp. 14-15) describes it thus: "In their feeding habits all species of catfish seem to be more or less nocturnal. They take a hook most readily from about twilight on into the night. Most set-line fishing is carried on at night.

Moon-lit nights, however, are more favorable than dark ones. On the St. Johns River it was noticed that the fish would begin to rise shortly after sunset, in large numbers, and the sound of their 'breaks' could be heard in all directions, although a lot of garbage thrown overboard would not fail to raise more or less of them during the day. The catfish here were wary of a baited hook, and, although freely eating of pieces of bread or meat floating at the surface, if a hook and line were attached, it would never be touched. Yet a hook baited with meat or fish and sunk would usually be satisfactorily effective, especially if 'bream' (*Lepomis*) began to bite first. The presence of other more readily biting fish seemed to attract the catfish and render them bolder. Large catfish would take a small baited 'bream' hook much more quickly than they would a large hook. The mud cat here bit no more readily than the channel cat. It might be well to state in this connection that the channel cats (*Ictalurus punctatus* and *Ictalurus furcatus*) are sufficiently game fighters to give an angler not too fastidious a very satisfactory battle. These two species might justly be classed as game fishes."

Hankinson has found these catfishes to be important as game fish in Central Illinois, where they are abundant in rivers, and are fished for in swift clear water chiefly in late spring and early summer. Minnows are the best bait, but sometimes they are caught with worms, grasshoppers, and crawfish. Henshall ('19, p. 246) gives a detailed account of methods of angling for the Channel Catfish.

References. Adams, '92; Baker, '16; Dyche, '14; Ellis, '14; Forbes, '88; Forbes and Richardson, '09; Hay, '94; Henshall, '19; Howard, '13; Jones, '84; Jordan, '85; Kendall, '04, '10; McAtee and Weed, '15; Moore, '20; Shira, '17; Surber, '13, '20; Ward, '94; Wetmore, '24; Wilson, '16.

Ameiurus nebulosus (LeSueur). COMMON BULLHEAD. One of the most abundant and valuable fishes though not rated among the fish aristocracy, nor highly valued by the sportsman, except when hungry; and yet one of the most important food fishes in the lake, particularly for the poor man. From other members of the catfish family found in Oneida Lake it can be distinguished by the following set of characters: tail not forked; adipose fin free from the caudal; anal fin rather short, usually with fewer than 24 rays and its ventral margin rounded; color tending to black and never yellow; lower barbels dark in color. (See plate 3.)

Breeding Habits and Life History. The life history and breeding habits of the Common Bullhead are among the most interesting to be found among the fishes of the lake. The Eel, sunfishes, bass, and sticklebacks are others sharing this unusual interest. The spawning is described as follows by Forbes and Richardson ('09, p. 189): "The brown bullhead spawns in spring, the time having been May in 1898 at Havana, Illinois (Craig). Their nests were found by Professor Birge in shallow bays with sandy bottom, 6 inches to 2 feet deep. The eggs are laid in masses similar to those of the frog, and are of a beautiful cream-color." We found no nests in Oneida Lake, but from testimony it appears that they might be found in early June or late in May. Wright and Allen ('13, p. 4) describe the breeding at Ithaca, N. Y., as in "sluggish, weedy, muddy streams and lakes, May 20 to July 1." Smith ('03) records aquarium observations on the breeding habits as follows: "They made a nest on July 3, 1902, by removing in their mouths upwards of a gallon of gravel from one end of the tank, leaving the slate bottom



Plate 3. COMMON BULLHEAD, *Ameiurus nebulosus* (LeSueur)

bare. On July 5, about 2,000 eggs in four separate agglutinated clusters, were deposited between 10 and 11 a. m. on the scrupulously clean bottom. Ninety-nine per cent hatched in five days in a mean water temperature of 77° F. The young remained on the bottom in dense masses until six days old, when they began to swim, at first rising vertically a few inches and immediately falling back. By the end of the seventh day they were swimming actively and most of them collected in a school just beneath the surface, where they remained for two days, afterward scattering. They first ate finely ground liver on the sixth day, and fed ravenously after the eighth day. The fish were 4 mm long when hatched, and grew rapidly, some being 18 mm long on the eleventh day, and at the age of two months their average length was 50 mm. Both parents were very zealous in caring for the eggs, keeping them agitated constantly by a gentle fanning motion of the lower fins. The most striking act in the care of the eggs was the sucking of the egg masses into the mouth and the blowing of them out with some force. The fanning and mouthing operations were continued with the fry until they swam freely, when the care of the young may be said to have ceased. During the first few days after hatching, the fry, banked in the corners of the tank, were at irregular intervals actively stirred by the barbels of the parents, usually the male. The predacious feeding-habits of the old fish gradually overcame the parental instinct; the tendency to suck the fry into their mouths continued, the inclination to spit them out diminished, so that the number of young dwindled daily and the 500 that had been left with their parents had completely disappeared in six weeks, although other food was liberally supplied."

For a fuller account of these observations see Smith and Harron ('04), also Eycleshymer ('01) and Gill ('07, pp. 442-448). Fowler ('17, p. 34) gives the following: "The nesting-habits of our common catfish or bullhead (*Ameiurus nebulosus*) are, perhaps, best known, and have been noticed by a number of observers. It nests in various situations, or in water from several feet in depth to that of but a few inches. Though only a few nests were noticed in a restricted area, sometimes a dozen or more may be found on one shoal and close to one another. Frequently the fish take advantage of any objects, such as logs, rocks, etc., for sheltering the nest. The eggs are deposited at intervals and may number from about 50 to 500 or more. In the construction of the nest, spawning habits and care of the young, this species is similar to the White Cat. There is always a great range of variation in many of these features, especially due to the individuals and conditions. No two nests were ever found exactly alike, and the same was true of the spawners. Even the female will sometimes, at least in the aquarium, brood her young, and in most cases the parents will devour the eggs, especially if disturbed. Usually the male guards the nest and broods the young, as the female deserts the nest by the time the young hatch. When just hatched the young catfish collect in a dense school, move in circles or close gyrations, the whole school in constant motion."

Our collections of very young *nebulosus*, that is, averaging under about 2 inches in length, are Nos. 76, 82, 113, 122, 155, 309, 607, 611, 617 and 4209. These lots consist of a single or of only a few specimens, except No. 122, which includes many; lot 309, several; and No. 607 includes about one and a half quarts of about

1½-inch fish. This large catch was found near shore in a loose ball or school, among rushes. Many escaped the net. We did not see attending adults. Lots averaging larger fish were Nos. 81, 100, 314, taken in September and October. In Michigan, Hankinson ('08, p. 208) on June 28 found in shallow water a school of these small Bullheads, about 1½ inches long, attended by adults 12 to 14 inches long. Weed and McAtee ('15, p. 9) note that both adults constantly guarded the nest, as they also did the carefully herded young for a fortnight or more. Evermann and Clark ('20, Vol. 1, p. 325) found the spawning time in the Lake Maxinkuckee region to be May and June. The eggs are relatively large and few in number and are placed under chunks of wood or sticks, the edges of rocks, or about the bases of water plants. They hatch in about five days, at a water temperature of 77°.

On June 19, 1921, Hankinson saw two compact schools of young Bullheads over sandy bottoms in very shallow water (1-8 inches deep) in two places close to the shore of Lower South Bay. An adult fish was seen attending one school. It was not very bold but remained on the shoal for most of the time, not permitting one to get nearer than ten feet or so. It moved about in a concerned manner, its center of interest being very clearly the compact mass of a thousand or more little Bullheads.

Habitat. The Common Bullhead is one of the most hardy fishes in the lake, belonging in this small group with the Eel, Mud Minnow and Carp. In a shallow, weed margined lake like Oneida, it is very generally distributed, as is indicated by our records, and in the tributary streams as well. Dean ('91, p. 302) gives a graphic account of its habitat: "Every trait of our catfish bespeaks its stagnant, mud-loving nature; dusky in color, sluggish and blundering. . . . A shallow, slowly drained pond, furnished with an occasional deep mud-hole, will suit admirably the needs of the fish. If the water does become warm in the summer, the catfish will survive; knowing how to survive is one of its special virtues. In a three-foot aquarium at college about a dozen nine-inch catfish were kept during very warm weather, the room temperature often in the nineties, and the water changed but once a day, with but few fatal results. Should the air supply in the water fail, trust the fish to care for itself. It will come to the surface, leisurely renew the air in its swim-bladder, or even, frog-like or turtle-like, swallow air in bulk, trusting to stomach respiration. Of undoubted respiratory value, moreover, must be the scaleless, highly vascular skin. . . . Should the pond dry, and the whole pond-basin be serried with mud-cracks, the catfish will lie dormant for days, even for weeks. It has been found in a clod of mud, which served as a cocoon, as with the *Lepidosiren*, until softened by the return of water. In winter the catfish, like frogs, and unlike many of its neighbors, appears to regularly hibernate. In November it becomes sluggish and refuses food, and early in December buries itself in the deepest ooze of the pond. It does not reappear till the 'first sharp thunder-storm' in February or March. Then they are seen thin and ravenous, approaching the shore so closely that their heads ripple the surface." Six young specimens (No. 82) were taken in a very shallow stagnant pond, overgrown with water plants and with a bottom of deep, black, foul-smelling mud, where the water was very warm. Its sole fish companion was the Mud Minnow.

Bensley ('15, p. 14), speaking of the Georgian Bay region of Lake Huron, states: "The fish is extremely common in all shore swamps and larger inland lakes of a swampy character, but is taken as a rule only at night." Fowler ('06, pp. 170-171) remarks that it is common in large rivers, large creeks, and small streams in New Jersey. He also states: "Though a good food-fish, it is frequently held in low esteem on account of its habits as a scavenger. It is to be found in either clear or muddy water if still, either in tide-water or above, and frequently numerous about the mouths of sewers. Those found in the smaller streams, brooks and ponds are often smaller, and in the latter, one may find them sometimes very abundant, or in large schools moving slowly along the bottom all closely herded together. They rest in the concavities of deep pools in this fashion, and it is seldom that a net fails to dislodge a number of them." Wright ('18, p. 540) says of the Common Bullhead: "This form is the most widespread in its distribution and most versatile in its adaptation of any of the three species of *Ameiurus* we have."

Food. The Common Bullhead feeds upon a large variety of food. Forbes ('88, pp. 460-461) examined the stomachs of 36 specimens; fishes comprised about 1/5 of their food, including a Yellow Perch and Sunfish. Mollusks, largely the mud inhabiting *Sphaerium*, included an equal amount. About 1/4 of the food consisted of insects, largely aquatic; considerable vegetable food was taken, and many crustaceans. Baker ('16, pp. 176-177) examined the stomachs of 7 Oneida Lake specimens and found that they had eaten plant material, crustaceans and insects. Hankinson ('08, p. 208) examined the food of 10 specimens, which consisted of small fish, crawfish, mollusks, entomostracans, leeches, midge larvae, beetles and the nymphs of May-flies and dragon-flies. Dean ('91, p. 303) states that "The stomach contents show its destructiveness to fish-eggs and to young fish." Forbes and Richardson ('09, p. 189) state: "The charge of spawn-eating has frequently been preferred against this fish, *A. nebulosus*, as well as its near relatives, especially by the whitefish and shad culturists. The evidence for such a view is, however, scanty." Mearns ('98, p. 312) states on the authority of G. S. Miller, Jr., that this Bullhead "commonly feeds upon seeds of the yellow water lily (*Nymphaea advena*) in ponds on Oneida Creek, central New York." Wilson ('20, p. 226) found adults eating dragon-fly nymphs. Evermann and Clark ('20, Vol. 1, p. 294) found water-lily seeds, fish, and other undetermined animal matter in twenty specimens examined from the Lake Maxinkuckee region. Later (p. 325) the authors note that this species feeds upon crawfish and soft-shelled mollusks, and in one case it had eaten a beach flea; and they also mention its reputation for feeding on eggs of other fishes. An *Ameiurus nebulosus* taken in Big Bay Creek disgorged a small Perch (No. 117). Bensley ('15, p. 14) remarks for Georgian Bay: "Throughout the summer the food consists almost wholly of Mayfly larvae, for which the fish burrows in the mud of the bottom." Smallwood ('18, p. 333) found this species at Lake Clear in the Adirondacks eating crawfish, clams, snails, *Plumatella*, and *Daphnia*. Greeley ('27, p. 57) records food of 17 of these catfish from Silver Lake of the Genesee System, N. Y. The food was entirely midge larvae, *Chironomus plumosus*.

Distribution Records. Our collection contains many specimens from Oneida Lake; No. 60, from Lower South Bay; No. 76, Scriba Creek, at the stripping house, Constantia; No. 81, ditch, north side of Johnson Bay; No. 82, small muddy pond at head of Johnson Bay; No. 100, west side of Walnut Point in Ladd Bay; No. 109, found dead in Oneida River, Brewerton; No. 113, Big Bay Creek; No. 122, Shaw's Bay; No. 129, west creek in Big Bay; No. 138, near Belknap's Landing; No. 142, Frederick Creek; No. 309, Lower South Bay; No. 311, off Constantia; No. 314, near cemetery, Brewerton; No. 368, Three Mile Bay; No. 409, Lower South Bay; No. 412, west side, Lakeport Bay; No. 416, along shore at Lakeport; No. 422, bay east of Mathews Point; Nos. 459 and 469, west side East Potter Bay; No. 471, bay east of Cleveland; No. 485, east side of Fairchild Bay; No. 488, Walnut Point; Nos. 489, 490, 492, Three Mile Bay; No. 505, west side, Upper South Bay; No. 512, Fish Creek, near Sylvan Beach; No. 513, Oneida Creek; No. 516, half mile above mouth, Fish Creek, near Sylvan Beach; No. 513, Oneida Creek; No. 516, Sylvan Beach; No. 524, Short Point Bay; No. 527, Chittenango Creek; No. 528, mouth of Chittenango Creek; No. 542, west side of Johnson's Bay; No. 544, Chittenango Creek; No. 553, small stream, West Vienna; No. 602, found dead in lake, south of Fairchild Bay; No. 607, young fish in school, west side of Shaw's Bay; No. 611, extreme western part of Lower South Bay; No. 617, near Coville's Landing, Brewerton; No. 621, creek on west side of Johnson Bay; No. 622, near Coville's Landing, Brewerton, Lamprey scarred, and No. 625, from same locality; No. 4209, Lower South Bay, June 19, 1921; about 12 large Common Bullheads were taken October 3, 1920, in about ten feet of water in Maple Bay.

Enemies and Disease. This species is well known and abundant, and for these reasons relatively much is known of its enemies and diseases. No doubt many of the statements about "bullheads," where no accurate determination has been made, apply to this species. The Common Bullhead is more susceptible to attack by the Lamprey than is any other fish in Oneida Lake, as has already been brought out under the discussion of the Lamprey. But the larger game fishes probably prey upon this bullhead, and the snapping turtle also is known to do so. A specimen (No. 368) of the common water snake (*Natrix sipedon*), 37 inches long, was taken with a 4-inch bullhead of this species in its mouth, in Three Mile Bay, August 3, 1916 (Eaton and Adams). The snake was among water plants near shore toward which it was swimming. At other times also this water snake was seen with captured bullheads the specific identity of which was not determined. Surface ('06, p. 155) records the capture of *nebulosus* by this water snake at Ithaca, N. Y. Fowler ('13, p. 12) states that the green heron, *Butorides virescens*, has been reported "to have swallowed a dead bullhead (*Ameiurus nebulosus*), though this is likely exceptional, living prey being preferred." Kendall ('17, p. 27) found two instances in Maine where this fish had been eaten by Chain Pickerel (*Esox niger*).

A trematode parasite, *Monostomum amiuri* Stafford, has been found in the air-bladder of the Common Bullhead (Stafford, '04, p. 495); *Phyllodistomum superbum* Stafford (l.c., p. 492) in the urinary bladder; and *Bunodera cornuta* Osborn ('13, p. 65) in "Bullheads" from Chautauqua Lake, probably has reference

to this species of bullhead. Faust ('18, p. 189) records a trematode, *Crepidostomum cornutum* (Osborn), as parasitic on *Ameiurus nebulosus* taken from Chautauqua Lake, New York. Marshall and Gilbert ('05, p. 517) report numerous cestodes from the body cavity and intestines, including *Corallobothrium* and *Proteocephalus*. They also record Acanthocephala from the intestine. Wilson ('19, p. 231) found *Ergasilus versicolor* Wilson on this catfish, and similar observations were made by Evermann and Clark ('20, Vol. 2, p. 80) at Lake Maxinkuckee. LaRue ('26, p. 285) and Butler ('19, p. 116) found larval trematodes in the eyes of these bullheads taken from Douglas Lake, Michigan. Several leeches were found attached to the fins of two specimens (No. 412) taken on the west side of Lakeport Bay. A dead bullhead (No. 92) was found in Maple Bay, with the intestine projecting from a lamprey wound, and a leech, *Haemopsis marmoratis* (Say), was attached to the wound surface (Baker, '16, p. 298).

Several parasitic copepods are recorded by Wilson: *Argulus maculosus* Wilson ('07a, p. 416; '19, p. 230); *Achteres pimelodi* Kroyer ('15, p. 628); *Ergasilus versicolor* Wilson ('11, p. 342; '16, p. 361); *Lernaeocera variabilis* Wilson ('16, pp. 338, 365); *Lernaeocera tortua* Killicott ('16, pp. 338, 368). Washburn ('86) describes the destruction of bullheads (*Ameiurus*) in Minnesota by what was probably *Argulus* (cf. Wilson, '04a, p. 119). The glochidia of the mussel *Quadrula* are recorded from the gills (Wilson, '16, p. 338) of this bullhead. Pratt ('23, p. 63) describes results of examining six of these fish from Oneida Lake, from which nematodes (*Spinitectus*), cestodes (*Corallobothrium* and *Proteocephalus*), trematodes (*Plagiorchus* and *Allocreadium*), and acanthocephalans (*Echinorhynchus*) were obtained.

Other diseased specimens in our collection are as follows: No. 422, with a fungus-like growth on the injured snout; No. 544, found swimming feebly near the surface, in Chittenonga Creek; No. 417, found swimming feebly near shore at Lakeport, its body with many deep sores in the skin, some of which had a bloody appearance; No. 490 has numerous yellow granules in the skin on the throat, bases of pectoral, ventral and anal fins. Evermann and Clark ('20, Vol. 2, pp. 79-80; Vol. 1, pp. 294, 326) found *Argulus maculosus* Wilson, *Ergasilus versicolor* Wilson, trematodes and Acanthocephala as parasites on this species.

Economic Relations. This is one of the most abundant fishes in the lake, is highly appreciated as a food fish and brings good prices. Large numbers are sold in Syracuse markets, mingled with a smaller number of *natalis* (Adams and Hankinson, '16, p. 159). It is the only member of the catfish family which the U. S. Bureau of Fisheries has cultivated successfully. The following quotation from Stranahan summarizes the main points on its culture (Kendall, '10, pp. 27-30): "Realizing that there is a growing interest in the catfish among the planters of the South and that the combination of bream and catfish is the best for ponds of small area, especially for those who want the fish for food rather than for show or sport, the writer determined early in the season to make a study of the breeding habits of the marbled catfish (*A. nebulosus*, the species hatched at this station), with a view of producing them in greater numbers than has been possible in the past.

"So far as our experience goes, and it has extended over twenty-five years in both the North and South, there is but one species of catfish that is really desirable

for pond culture, especially if the area of water is restricted, and that is *A. nebulosus*, or what is usually known as the bullhead or horned pout and marble catfish in the North (although all of the small catfishes are called bullheads in the North) and speckled catfish in the South. All attempts, so far as we know, to domesticate and successfully rear the channel cat (*Ictalurus punctatus*) in small areas of water have utterly failed.

"The people of the whole country, and especially of the central South, regard the catfishes favorably, and the interest in them is surely growing. This being true, it follows that an effort should be made to produce them in greater numbers than has been done in the past.

"After observing results for several years it seems clear to us that the catfish under consideration (*A. nebulosus*) does better in wild ponds, even of small area, than in those that have been established with much care and pains.

"It has been noted at this station, especially in pond M, where conditions are favorable, that the catfish like some such cover as a sunken log or stump. Accordingly it was determined to place sunken boards in the ponds where these fish were kept, in such numbers that each individual fish should have a home of his own as well as a nesting place. The water in the ponds was drawn to near the bottom and inch boards 12 inches wide and 5 or 6 feet long were used, one end being driven into the embankment a few inches, the other end being fastened to the bottom by driving a 1 by 3 inch stake down at the end and nailing through this into the board. In most cases this left an opening under the center of the board, but where it did not the catfish very soon dug out the earth and made the place to suit themselves. In fact, the writer would recommend that this feature be left to the fish, for it was observed that they dug out the earth and occupied these boards, which were flat on the bottom, before they did the ones along the embankment where an opening was all ready for them. We shall also in the future use a board about 3 feet long, as that proves ample for the needs of the fish, requires less lumber, and is less in the way during seining operations. The board should also be well tramped down into the mud so that the stakes will not hang the seine, the stake and board being a little below the general level of the bottom of the pond. If put in thus, it might be well to make the beginning of a depression under the board with a shovel or mattock, as otherwise the board might be overlooked by the fish. This, however, is not likely.

"I would here make a special note, special because I believe that it is important in the production of bullheads in numbers. Although the fish ordinarily use the boards in spawning, it was noted that early in the season while the water was yet cool they did not use these, but resorted to the shallows of the ponds where the water is about a foot deep and there established their beds, making a depression in the mud and weeds shaped like a track made by a moccasin-covered foot, the depression being about 18 inches long and 6 wide at the broader end. The parent fish, with their heads to the broader end of the depression, here deposit the eggs. We had no boards in water less than 2 feet in depth, but by accident one board was left on the embankment with one end in the pond in about 6 inches of water. This was early occupied by a pair of catfish and a large brood produced.

"All this demonstrates that to be most effective a portion of the boards should be in the shallow water for the use of early spawners. It also strongly suggests that the flow of water into the pond should be so regulated as to produce the highest temperatures attainable in the early part of the season. In the morning the supply should be reduced or cut off entirely, while at night, when the water may be warmer than the air, it should be turned on in full supply.

"In this connection I would recommend that where practicable water for the supply of catfish ponds would best be taken from some other pond, so that a higher temperature may be maintained, especially early in the season and during periods of low atmospheric temperature. We have about 32 or 33 catfish in each of our ponds K and M, the former being of about twice the area of the latter. K is supplied direct from the springs, M from a 2-inch iron pipe from pond L, one of our largest and warmest ponds. The catfish hatch has been more than double in M what it has been in K and, for all we know, one pond is as favorable for the fish as the other, both having muddy bottoms and an abundance of vegetable growth. We believe that the temperature of the two ponds is responsible for the difference. As soon as the weather grew hot all of the beds were placed under boards in 2 or 3 feet of water and not one in the shallows.

"This matter of temperature may account for the unfavorable results some seasons when practically no catfish are hatched in even the wild ponds, and other conditions than temperature may also have a controlling influence. It is probable that muddy water would be unfavorable and even low atmospheric pressure also, fishes being more susceptible to changes of pressure than air-breathing animals.

"From the start we have watched developments in our catfish ponds K and M. The first point of special note is that the fish were seen spawning about a month earlier than usual, although it must be admitted that a much closer watch was kept (daily, almost hourly) than ever before. It has been suggested that possibly the contentment brought by the homes afforded by the boards may have had some influence in favoring reproduction. At all events our hatch has been more successful than for the past six or seven years, and we know of no other cause to ascribe it to.

"Our first surprise was at the short period of incubation of the eggs. Based on temperature and the period of other fishes, the time should have been about 24 to 30 hours, but these catfish eggs hatched in less than 20 hours. How much less we do not know, but every effort to find out positively will be made during the remainder of this season and next. In the two cases observed so far this season we were thwarted in getting the exact time by the fish coming off unexpectedly early in the morning or in the night. The temperature of the water at the beds in both cases under observation was $77\frac{1}{2}^{\circ}$ to $78\frac{1}{2}^{\circ}$ F., varying with the time of day.

"The first case closely watched was on May 8, when at 9.30 a. m. a female catfish was seen in a depression, such as previously described, in about 12 inches of water and 3 feet from shore, in fine position for close observation. She was over a quantity of light orange-colored eggs, forming a gelatinous mass about 4 inches wide and 5 long and apparently three-fourths of an inch thick or deep. They had every appearance of being freshly deposited, the water still being somewhat muddy owing to the digging of the depression. The male was lying some three feet away

with apparent unconcern. At 7:30 the next morning both fish and eggs were gone from this spot, but lying some 10 feet away was a female with a brood of very small young, the male being near by and the fry inactive as they invariably are when just hatched. These adult fish had every appearance of the ones observed the day before.

"The second and last case observed was a better one than the former for reasons that will be obvious to the reader. On May 13, at 9:30 a. m. the writer discovered a pair of catfish in a depression, as before described, in about a foot of water and 6 feet from shore. The fish were lying side by side, about an inch apart and apparently inactive. There were no tremors or other evidence of an orgasm, so apparent in the case of black bass and other fishes in the act of depositing spawn and impregnating it, and there were no eggs visible on the bed, although the mud on the bottom between the fish and at each side of them could be plainly seen. After a little less than an hour, during which, unavoidably, watch was kept for only about fifteen minutes, the male was found off the nest a short distance away and the female in the center of the bed over a bunch of eggs such as is described in the former case. It is regrettable that continual watch was not kept, and a further shortcoming in observation is also to be deplored. At 7:30 the next morning the fish and the eggs were gone and, as in the former case, the female with a brood and the male standing guard were some 10 or 12 feet from the vacated bed. In the former case the writer assumed that the eggs had been deposited a few hours before discovered and that at least 24 hours would be required for hatching. This led in the second case to a reckoning on his part that the eggs would not be hatched when he went on duty at 7:30 a. m., an error which will have to be corrected by further observation. This is the more a pity, as the opportunity was good for determining the exact period of incubation with this fish in a given temperature of water.

"It should be stated that this last lot of eggs was watched from time to time during the day and that but little change was noted. Late in the afternoon, almost sundown, it was thought that the egg mass was somewhat darker, especially around the edges.

"During these observations we have arrived at the conclusion that the female of this species broods the eggs during incubation and cares for the young after they are hatched, the male remaining near by in either case and acting apparently as a guard. This opinion as to the division of parental duties is based on the fact that it is the larger fish that broods the eggs and cares for the young, the smaller one standing guard and that, without a single exception in our observations of several broods, the small, or guard fish, has an ugly wound on the top of his head well back of the eyes, where the teeth of his antagonist would come when the jaws of the two are locked, head on, in their fights for the possession of the females. This is the opinion of the commercial fishermen at Chautauqua Lake, New York, where many male fish are found locked together, dead or dying, during the breeding season. We have observed no deaths from this cause, and the fact that all fish that we call guards are wounded as described would seem to indicate that they lock and then break away and lock again, thus giving each combatant a chance to have a sore head.

"As with the black bass, and doubtless many other fishes, there is as much difference in these female catfish on the point of being good or poor mothers as there is in the case of hens or human beings. One mother will be seen working continually stirring up the mud to procure food for the fry, rounding them up when a portion of the brood wanders away and keeping the school together until they have grown to an inch and a half in length and are as large around as a lead pencil, while another fish, probably of the same age and size, will leave its young to stir up the mud for themselves, allow them to break up into small schools, and finally will abandon them entirely. They then wander about in small bands or are incorporated with some other brood.

"Another very interesting feature in the breeding habits of this fish is that schools of about the same age, or, say, within a week of each other, coalesce, all in the pond forming into one school. In ponds K and M there were several early broods in each pond. These remained with their respective parents until they had attained some size and become active in their search for food, when they consolidated into one large school in each pond and so remained until collected for shipment. The ponds were so clear and the black mass of moving fry so easily seen that there was no doubt about the correctness of this observation. The later hatches remained with their parent fish, not joining with the older broods, but subsequently they sought other broods of about their own age, thus again forming another large school.

"Some experiments have been made in feeding these small catfish, with a view to holding them in fry ponds, all former attempts in this direction having failed. Well-cooked corn mush thinned down to a gruel was distributed in a narrow line along the margin on one whole side of a pond, and at the termination of the trail a considerable field, say, 8 or 10 feet square, was moderately covered with the feed. The fragmentary schools—those broken up through poor maternity or other causes—would strike these trails, follow them as a hound would follow a rabbit track, and then clean up all of the feed on the field referred to. They also greedily devour finely ground mullet. It is believed by the writer that excellent results may be attained through a judicious system of feeding both the old and young of this species. As the adults are not pugnacious, except the males during breeding season, we believe that 100 adults could easily and successfully be carried in each of our ponds by giving each a board home and supplying them a suitable quantity, with some variety, of proper food—say cut mullet, with liver for a change. These fish are not subject to epidemics, are easily raised in ponds, finding much of their own food, and are easily captured when wanted."

Angling. Bullheads may be readily caught over muddy bottoms where there is considerable aquatic vegetation, by using hook baited with raw beef, worms, or minnows. They bite best at night, and according to Hankinson's experience in Michigan lakes, they are rarely taken during the day time. Hankinson has caught many of these and Yellow Bullheads from a millpond in Michigan, with a chunk of beef tied on a line and with no hook. Often two fish would be pulled in at one time persistently clinging to the meat. No angling for bullheads was done by us in Oneida Lake. Mr. George H. Travis informed us that they are readily taken by set line, and the use of these lines with no more than 300 hooks is legalized by

paying a license fee of one dollar. One end of the line must be on shore and must bear the license number.

References. Adams and Hankinson, '16; Baker, '16; Bean, '91; Bensley, '15; Butler, '19; Eycleshymer, '01; Forbes, '88; Forbes and Richardson, '09; Faust, '18; Fowler, '06, '07, '13, '17; Gill, '07; Greeley, '27; Hankinson, '08; LaRue, '26; Mearns, '98; Marshall and Gilbert, '05; Kendall, '04, '10; McAtee and Weed, '15; Moore, '22; Osborn, '03; Pearse, '21; Pratt, '23; Surface, '06; Smith, '03; Smith and Harron, '04; Stafford, '04; Washburn, '86; Wetmore, '24; Wilson, '04, '07a, '11, '15, '16, '19; Wright and Allen, '13.

Ameiurus natalis (LeSueur). **YELLOW BULLHEAD.** Apparently not particularly abundant in Oneida Lake, but is probably often confused with the Common Bullhead, from which it may be distinguished by its decidedly yellowish color, broader and more compressed caudal peduncle and longer anal fin, which has about 25 rays and a nearly straight ventral margin. Hubbs has called our attention to the fact that this species has pale barbels, making it easy to distinguish.

Breeding Habits and Life History. This species is not well known. Wallace Craig found it spawning in May in Illinois, according to Forbes and Richardson ('09, p. 186); and Richardson ('13, p. 410) records finding the fish with ripe spawn in May and June. Fowler ('17, p. 33) writes: "The spawning habits of the yellow cat (*Ameiurus natalis*) are similar to those of the common catfish. The nest is a hollow or small excavation usually but little larger than the fish, or it may be situated in a hole or burrow. If a burrow is used it may extend from an inclined depth of two feet. It is excavated as a nest by the labor of both sexes. The spawning season is of about two weeks extent or from May 15 to June 1." Mr. R. E. Van Dusen, who has found the burrow-like nests of this species in western New York, noticed that often small roots from the surrounding vegetation would be left in the burrow, and frequently served as an anchorage for the yellowish-white adhesive eggs. The latter are deposited usually to the extent of about 300 to 700 in a nest. The male guards and broods the young, and, when the latter leave the nest, cares for his charges for some time. Wright and Allen ('13, p. 4) give the breeding season at Ithaca, N. Y., as May to June 20th, the nest being made under boards, in cans and under crockery. Forbes and Richardson ('09, p. 186) give the maximum weight of this species as from 1½ to 2 pounds.

Habitat. Bean ('02, p. 272) states that it is "most abundant in sluggish streams," and Hankinson ('08, p. 208), that it "seemed generally frequent in the pond-weed zone, from which it went into shallow water at night." Small individuals were common in shallow water in dense vegetation. Forbes and Richardson ('09, p. 185) thus describe the habitat: "It is commonest in creeks, and next in lowland lakes. . . . In local distribution it contrasts in an interesting way with the brown bullhead, *A. nebulosus*, which is much the commonest in lakes and ponds, and comparatively scarce in creeks." Hankinson ('13, p. 108) remarks that in Illinois "large numbers of the very young of this species are often found in small creeks; the adults prefer larger streams." Evermann and Clark ('20, Vol. 1, p. 324) found the fish over soft bottom in Lake Maxinkuckee, usually in water from 5 to 15 feet deep. In the autumn the young appeared to be fond of hiding under logs and stones in shallow water.

Food. The food, as revealed by the stomach contents of four specimens, consists of crawfish and insects, according to Hankinson ('08, p. 208). A dozen specimens examined by Forbes and Richardson ('09, p. 186; Forbes, '88, p. 459) showed the fish to be a scavenger, and fresh materials included crawfish, insects, snails, Entomostraca, and some water plants. Baker ('16, p. 175) found in the stomach of Oneida Lake specimens (No. 327) insects, algae, *Ancylus* and detritus. Another specimen (No. 516), 8.25 inches long, was found by us to contain a crawfish (*Cambarus*) claw, a Yellow Perch, (*Perca flavescens*) about 2½ inches long, and a small piece of grass. Kreckler ('19, p. 453) found shells of *Physa*, May-fly nymphs and considerable algae in a fish from a pond near Sandusky, Ohio. Small fish and crawfish were the principal food of 122 specimens of the Catfish from Lake Maxinkuckee and vicinity (Evermann and Clark, '20, Vol. 1, pp. 294, 325).

Surber ('20, p. 17) says that it is a scavenger, eating everything found in the water: minnows, crawfish, insect larvae, snails by preference. The young feed principally on Entomostraca and insect larvae. Pearse ('21, p. 263) reports on the food of two fish of this species, each nearly a foot long, from Green Lake, Wisconsin. About a third of the food was fish and about a third insects. Crawfish, amphipods, entomostracans, and plants made up the rest.

Distribution Records. No. 81, from small ditch emptying into Johnson's Bay; No. 122, Shaw's Bay; No. 124, Fairchild Bay; one large specimen, No. 128, Big Bay Creek; No. 138, near Belknap Landing; No. 309, Lower South Bay; No. 516, Fish Creek; No. 563, small creek at head of Big Bay; No. 622, Coville's Landing, Brewerton. A total of 17 specimens are in our collection.

Enemies and Disease. No records have been found of this fish being taken by predacious animals, although doubtless it frequently happens. Two parasitic copepods are recorded by Wilson from this bullhead, namely, *Argulus maculosus* Wilson ('07, p. 416; '16, p. 354; '19, pp. 230, 231) and *Ergasilus versicolor* Wilson, attached to the gills ('16, p. 338). He also records the glochidia of *Anodonta corpulenta* on the fins, and *Quadrula* on the gills ('16, p. 338). Surber ('13, p. 103) states that "a catfish (*Ameiurus natalis*) carries a few glochidia of the *Quadrula* type." Stiles ('94, p. 175) found a protozoan, *Holophrya multifiliis* (Fouquet), infesting this fish. Leeches, trematodes and Acanthocephala were the chief parasites found by Evermann and Clark ('20, Vol. 1, p. 294; Vol. 2, pp. 79-80).

Economic Relations. The relative scarcity of the Yellow Bullhead in many regions, and the fact that few distinguish it from the Common Bullhead, makes it difficult to secure accurate details concerning this species. Forbes and Richardson ('09, p. 186) state that the thin skin makes this fish "particularly hard to dress." It is reported by Hankinson ('13, p. 108) that in Illinois it is "frequently taken by hook from deep holes in the rivers, and from similar places in creeks."

References. Baker, '16; Bean, '02; Evermann and Clark, '20; Forbes, '88; Forbes and Richardson, '09; '13; Fowler, '13, '17; Hankinson, '08, '13; Kendall, '10; Kreckler, '19; Richardson, '13; Stiles, '94; Surber, '94, '13, '20; Wilson, '07, '16, '19; Wright and Allen, '13.

Schilbeodes gyrinus (Mitchill). **STONECAT.** A small, rather rare fish in Oneida Lake, valuable as bass bait, but armed with a sharp spine and a poison gland which are capable of producing a painful wound.

Breeding Habits and Life History. On June 26, in Southern Michigan, Hankinson ('08, p. 208, Pl. 59) found a fish of this species $2\frac{3}{8}$ inches long, guarding a cluster of eggs in an old tin can. Wright and Allen ('13, p. 4) give for Ithaca, N. Y., the following breeding season and conditions: "May-July 1. Nest under board, in cans, under crockery." Forbes and Richardson ('09, p. 198) state that in Illinois, "Males and females taken by us June 8 were already spent, and the spawning season probably falls in May." Richardson ('13, p. 411) found nearly ripe eggs, July 1, in Illinois. Evermann and Clark ('20, p. 332) say the fish apparently spawns in June and July, in Lake Maxinkuckee.

Habitat. The habitat of this species is in "Still and muddy waters" rather than in those with "rapid current and a clean bottom," and Hay ('94, p. 173) states that "It is accustomed to hide about and under stones and logs."

Food. The food of the Stonecat, based on the study of 13 specimens, was found by Forbes ('88, p. 462) to consist almost wholly of animal food, largely of aquatic Crustacea, but a single small fish was found with it. Hankinson ('09, p. 208) found the food in one specimen to consist largely of insect fragments. Pearse ('15, p. 15) found the food of five fish examined to consist mainly of insects and small Crustacea, and a small amount of vegetable material. Evermann and Clark ('20, pp. 294, 332) found them eating small crustaceans that were plentiful in the *Chara* where the little catfish were lying. Pearse ('18, p. 274) gives detailed findings from the examination of 55 examples of this species. His summary is as follows: insect larvae, 36%; pupae, 4.4%; adult insects, 3.6%; mites and amphipods, 10.3%; entomostracans, 18%; oligochaete worms, 18.3%; snails, .1%; plant material, 6%; silt and debris, 3%.

Distribution Records. Our few Oneida records are as follows: No. 120, Big Bay Shoal, near Belknaps Landing; No. 314, in shallow water near cemetery, Brewerton; No. 412, west side of Lakeport Bay; No. 602, found dead south of Fairchild Bay; No. 622, from Coville's Landing, Brewerton; No. 626, outlet of Oneida Lake, Brewerton. Most of our specimens are small, only 3 being over 3 inches long.

Enemies. Evermann and Clark ('20, p. 297) note this catfish eaten by Rock Bass.

Economic Relations. On account of its small size and small numbers the Stonecat is of slight direct economic importance. It probably serves as food for other fishes and is valuable for bass-bait. According to Bean ('03, p. 94): "The species is too small to be of any value except for bait, and on account of its tenacity of life it is greatly in demand for hook and line fishing, especially in the capture of the black bass, for which it is one of the best baits known." A distinct disadvantage against widespread popularity of this fish as bait is its painfully poisonous sting, produced by the spine on the anterior edge of the pectoral fins. The poison glands have been given special study by Reed ('07, pp. 555-556) who writes: "The sting of the mad toms has been described as like that of the bee. In *Schilbeodes gyrinus* the sensations produced do not differ materially from those

of a bee but as a rule the pain is not so intense and is usually confined to the wounded region. Frequently a very severe sting upon the end of the finger caused pain throughout the hand and wrist. In several cases after receiving deep punctures on the end of the finger sharp pains which continued for several hours were experienced to the elbow. Dr. Evermann (MS.) describes the pain as a 'very stinging sensation, more like that which would result from a severe nettle sting.' This describes precisely the majority of stings, for in handling live specimens ordinarily only the tip of the spine enters the flesh. The mechanical injury is so slight that frequently it is impossible to discover the wound except for the stinging sensation. From an ordinary sting such as is received in handling the live fish, the pain continues from one to several hours, depending probably upon the amount of poison entering the wound. Both in sensation and duration these wounds differ from those made by a prick or puncture of a sharply pointed instrument. The swelling is hardly perceptible, except in the case of very severe punctures, in which event the flesh about the wound becomes distinctly swollen and slightly discolored. Similar results, but more marked, are produced by introducing a portion of a fresh gland underneath the skin." *Schilbeodes gyrinus* was the only species available for experimentation. Some other species of the genus are said to be more poisonous.

References. Bean, '03; Evermann and Clark, '20; Forbes, '88; Forbes and Richardson, '09; Hankinson, '08; Hay, '94; Pearse, '15, '18; Richardson, '13; Reed, '07; Wright and Allen, '13.

Schilbeodes miurus (Jordan). VARIEGATED STONECAT, BRIDLED STONECAT. The most imperfectly known of the silurids which we took in the lake. Nothing has been found recorded on its breeding habits. It is easily distinguished from *S. gyrinus* by its mottled coloration.

Habitat. In habitat this species, according to Forbes and Richardson ('09, p. 200), "agrees closely with *flavus* in its ecological preferences, being, like that species, found only in running streams (but most abundantly in creeks) and absent, so far as our observations go, from standing waters. It likewise agrees with *flavus* in its preference for a clean bottom and a swift current." Hankinson ('13, p. 109) found it on the rocky bottom of a river and its larger tributaries. Our largest specimens were taken from Oneida Lake; and in the shallow water of its outlet, at Coville's Landing, Brewerton, small young were taken. Upon the wave-washed bouldery shores it probably finds the conditions similar to those in streams.

Food. The only information recorded on the food is that by Baker ('16, p. 177), in respect to a single specimen (No. 309) from Lower South Bay, Oneida Lake, which contained "only algae and mud."

Distribution Records. We have secured only seven specimens of the Bridled Stonecat: No. 309, South Bay; No. 103, Ladd's Point; No. 561, Paddygut Bay; No. 604, in a sandy bay between Wedgeworth Point and Fairchild Bay; Nos. 622 and 626, from Coville's Landing, Brewerton. Four of these seven specimens were found dead.

Economic Relations. The Variegated Stonecat is too small and rare to be of food value. Hay ('94, p. 174) remarks that "it is said to form an attractive species for the aquarium." (Cf. E. Smith, '02, p. 96.)

References. Baker, '16; Forbes and Richardson, '09; Hay, '94; Hankinson, '13; E. Smith, '02.

Umbra Limi (Kirtland). MUD MINNOW. The Mud Minnow (Fig. 201) is a little known fish usually found in sluggish creeks, sloughs, marshes and like conditions where there is an abundance of submerged or partly submerged vegetation and considerable bottom mud. Here it moves about and feeds, finds safety and hibernates. In general appearance it is much like a small Bowfin, but is readily distinguished by its short dorsal fin and the absence of the gular plate. In spite of its unattractive habitat it is a fish of considerable beauty, as is revealed in an aquarium, where it lives and feeds readily. It is undoubtedly abundant in Oneida Lake, but the character of its habitat and its way of hiding makes it difficult to capture, so that our collections have but few of them. It is one of the most adaptable of our fishes, and can probably live under a greater variety of conditions than any of the others except possibly the Eel or the Bullhead.

Breeding Habits and Life History. Mud Minnows spawn in early spring, in March and April, according to Forbes and Richardson ('09, p. 204), and from March 16 to April 7 at Ithaca, N. Y. (Wright and Allen, '13, p. 5). Abbott ('90, p. 393) and Gill ('04, p. 302) also discuss the breeding habits. Mud Minnows run up into the waters of swift hillside brooks during the breeding time (if these flow into ponds or marshes), going up miniature cascades to seek the most distant parts of streams, where they can be seen lying half hidden among the pebbles and sandy ridges in the bed of the brook. The females appear to run in advance of the males, and the sexes segregate as a preliminary to entering the breeding streams. If creeks are not available they lay their eggs in the ponds or marshes and attach them by their adhesive coats to aquatic plants. On March 26, 1921, Hankinson saw a number of Mud Minnows in a small creek tributary to Muskrat Bay, where the creek flowed through open fields of upland. They were evidently on the spawning migration. The water temperature was 60° F.

Habitat. Mud Minnows are almost always found where water plants are abundant, except at spawning time when they may leave situations of this character for clear rapid streams (Gill, '04, p. 302). In Oneida Lake we took but two of these fish, one (No. 569) among algae and water willow growth over a cobble-sand bottom at Poddygut Bay, and one (No. 594) under similar vegetation and bottom conditions at or near the mouth of the stream at West Vienna. There was very little mud at either of these places. We took ten Mud Minnows in four creek collections (Nos. 81, 116, 511, 621). In all cases there was much vegetation, grass, sedge, swamp loose-strife, cat-tails, bulrushes, and other plants, and a mud bottom. One (No. 82) was taken in an isolated pool near Johnson's Bay, having mud bottom and a growth of bulrushes and cat-tails. The only other species found here was the small bullhead, *Ambloplites nebulosus*.

Abbott ('09, p. 392) and Gill ('04, p. 300) show how much these minnows depend on mud for their existence, disappearing into it, tail first, when danger approaches. To catch them one must, therefore, stir up the mud while one is

using the net. They hibernate in this soft bottom mud, going down 4 to 9 inches, and may be found dormant in it, lying with the head upward in either a vertical or a nearly horizontal position, making it apparent that they burrowed tail first. When the water is receding in their habitat they are capable of jumping from one pool to another, and eventually protect themselves by burrowing as in hibernation. Mud Minnows may be seen resting on the bottom or moving slowly over it, making peculiar tracks. They can pass through soft mud with remarkable ease. Bean ('92, p. 88) says: "It has been stated that this fish has been plowed up in ponds and swamps which have dried out." Forbes and Richardson ('09, pp. 204-205) found it most frequently in lakes and ponds and next in the smaller rivers. They quote Baird as saying that a water that is perfectly clear and apparently destitute of fish, will perhaps yield a number of Mud Minnows, on stirring up the bottom mud and drawing a seine through it; and that ditches on the plains of Wisconsin, or mere bog holes containing apparently nothing but tadpoles, may be found actually to contain quantities of Mud Minnows. Shelford ('13, p. 142) found them in *Chara* beds in ponds near Chicago. Fowler ('06, p. 182) notes the darker colors of those found in cedar stained waters compared with those from paler waters or clear streams, and thinks these fish are capable of changing their color somewhat. Evermann and Clark ('20, Vol. 1, p. 257) record the species from deep water, 14-16 feet, in Lake Maxinkuckee.

Food. Forbes ('83, p. 73) gives the results of examining the food of ten Illinois specimens. Vegetable food amounted to 40%, chiefly *Wolffia*, and some algae; mollusks, insects, entomostracans and amphipods constituted the remainder. Pearse ('15, p. 19) examined 50 specimens from Wisconsin and found that they had eaten dipterous larvae including *Chironomus*, *Tanytus*, and others, with caddice-fly larvae, lepidopterous larvae, midges, Hemiptera, mites, amphipods, entomostracans, mollusks, and plant material including seeds and filamentous algae. Abbott ('90, p. 396) says: "The Mud Minnow is carnivorous. When kept in aquaria they will devour any reasonable number of flies offered them, and undertake, without hesitation, to swallow earthworms as large as themselves. Once they take hold of a worm they never let go, but at least secure that portion of the animal between their jaws. . . . Unlike any other of our fishes the mud minnow will leap twice or thrice its length above the surface of the water to seize a fly or beetle that rests upon some overhanging blade of grass or twig. . . . It is probable that much of the vegetable matter found in their stomachs has not been taken voluntarily but unavoidably; the fish swallowing portions of a plant often for the sake of the animal life that was clinging to it." Hankinson ('08, p. 209) found entomostracans, green algae, water mites, midge, *Planorbis* shells, and miscellaneous insect material in four specimens. Evermann and Clark ('20, Vol. 2, p. 168) found that 60% of the stomach contents of a Mud Minnow consisted of *Wolffia*. Pearse ('18, p. 276) gives results of food examinations of 110 specimens, which are summarized as follows: insect larvae, 21.9%; pupae, 2.1%; adult insects, 10.9%; spiders, .1%; mites, 1.2%; amphipods, 6.5%; entomostracans, 28%; snails, 2.3%; Sphaeridae, .1%; oligochaete worms, 2.9%; leeches, 1.1%; nematodes, .4%; rotifers, 2%; protozoans, .2%; plants, 21.5%; algae, 11.1%. Greeley ('27, p. 62) found insect larvae, including a beetle larva,

and small crustaceans in two Mud Minnows from Black Creek, Monroe County, N. Y.

Distribution Records. In shallow water near shore we got two collections with this species, No. 569, Poddygut Bay, 1 fish; and No. 594, Eaton Bay, 1 fish. Stream collections are No. 81, Johnson's Bay Creek, 1 fish; No. 116, creek west of Little Bay Creek, 5 fish; No. 511, Oneida Creek, 1 fish; No. 621, Johnson's Bay Creek, 1 fish; and No. 82, from an isolated pool near Johnson's Bay, 1 fish.

Enemies and Disease. A Mud Minnow was found in the stomach of a young Chain Pickerel caught at Thrice Mile Bay, July 3, 1916. Bean ('92, p. 88) says that it is of value as food for other species of fish. Abbott ('90, p. 391), in describing its habit of burying itself in the mud during draught and among moist grass roots, quotes Zadoc Thompson to the effect that in these situations vast numbers of this species are devoured by birds, muskrats and foxes. Hankinson ('16, p. 148) found one in the stomach of a pike, *Esox lucius*, caught in a small lake at Whitefish Point, Michigan. Wilson ('16, p. 355) notes that a parasitic copepod, *Argulus americanus* Wilson, infests the Mud Minnow.

Economic Relations. Mud Minnows are superior to all of our other small fishes for bait only in their tenacity of life. Evermann ('01, p. 344) describes this quality as follows: "So persistently do they cling to life that it is really difficult to kill them. In a live-box (for which any old barrel answers admirably), minnow-bucket, or on the hook, it will live indefinitely; indeed, unless seriously bitten or swallowed outright by some game-fish, a single Mudfish can be fished with for several days if not for the entire season! Its unexcelled tenacity of life is, however, about the only thing it has to recommend it as a bait minnow. Its somber, unattractive color prevents it being readily seen by game-fishes, and its tendency to pull down or get to the bottom also militates against it. But bass and pickerel and pike do sometimes take it, and, in spite of its deficiencies, the Mudfish is a good thing to have in one's minnow pail."

Its ability to live under many conditions makes it easy of transfer from a natural habitat to an aquarium, where it is attractive in appearance and has some interesting features of behavior (Gill, '04, p. 300), as when it suspends itself apparently motionless above the bottom and assumes various peculiar attitudes of body. It takes food readily here (l.c.), including small shreds of meat as well as natural food, and it will leap above water and take tempting morsels from the hand.

On account of its ability to hide and the impenetrability of its usual habitat, it is not likely that it is very important as food for the valuable large fishes in Oneida Lake. Pettit ('02, p. 9) noted mosquito larvae scarce in pools where Mud Minnows were found, in comparison with those where they were absent.

References. Abbott, '70, '90; Bean, '92; Evermann, '01; Forbes, '83; Fowler, '06; Forbes and Richardson, '09; Gill, '04; Greeley, '27; Hankinson, '08, '16; Jordan, '82; Nash, '08; Pearse, '16, '18; Pettit, '02; Shelford, '13; White, '19; Wilson, '16; Wright and Allen, '13.

Esox niger LeSueur. CHAIN PICKEREL, EASTERN PICKEREL. The Chain Pickerel (Plate 4) is the common pickerel of Oneida Lake, and usually known there as the "Grass Pickerel." It has also been called the "Federation Pike of Oneida Lake" (Bean, '03, p. 297). This pickerel is one of the popular game



Plate 4. CHAIN PICKEREL, *Esox niger* LeSueur.

fishes of the lake. Of the two members of the genus *Esox* found there, this one is readily distinguished by the presence of scales on both the upper and lower halves of the operculum and of the cheek, and mature examples can probably always be identified by the reticulated character of the markings on the sides of the body instead of the rather distinct spots of *Esox lucius*. However, there is great variation in the markings in different localities and under different light conditions.

Breeding Habits and Life History. According to testimony, pickerel come to the shallow water of the many marshes about Oneida Lake to spawn early in the spring, about the time the ice begins to disappear from the shore region. In 1920, they evidently bred about April 1. Embury ('18, p. 253) notes that pike and pickerel usually enter the marshes and temporarily submerged fields at the southern end of Cayuga Lake as soon as the ice leaves, which is usually toward the end of March, and that spawning occurs a week or more later when the water temperature approaches 47° F. The pickerel apparently breeds a little later than the pike, but the two may be spawning at the same time. Wright and Allen ('13, p. 5) give the breeding time for the Chain Pickerel as February to June 1. The actual spawning time evidently varies with latitude and with the character of the particular spring season. According to Kendall ('17, p. 28) ripe fish were found in Massachusetts in May, in Pennsylvania in April and early May. Ryder ('87, p. 516) furnishes notes on the embryology of this species.

Kendall ('17, p. 28) says that the breeding places are shallow coves, mouths of inlets, approaches to outlets, and sometimes overflowed areas, in water from 3 to 10 feet deep, but not always in the same places each year; and further, that sometimes the eggs are deposited among the roots of submerged tree stumps, the branches of fallen trees or bushes, water plants, and occasionally on gravel or in crevices among rocks. He quotes Tomlin ('92) who says the fish are found in pairs, gently swimming to and fro, sides touching, until the female is ready to spawn. The eggs are laid in glutinous strings of a yellowish color, which often form large masses clinging to submerged objects. Sometimes the strings are as long as nine feet. In Massachusetts it was noted (l.c., p. 29) that females appear to preponderate over males. Embury ('18, p. 253) describes the spawning of Pike and Pickerel, which, he says, are practically identical in their spawning behavior, as follows: "A female, accompanied by one or more males swims about in a meandering path. Eggs and milt are cast during widely varying intervals and at each emission violent lashings of their tails tend to distribute both eggs and milt over a comparatively large area." He notes that spawning Pickerel have been observed crossing the paths of spawning Pike (*Esox lucius*) and considers it conceivable that cross fertilization may take place, resulting in hybrids of the two species.

In Oneida Lake, the Chain Pickerel noted by us have all been small, the larger ones taken ranging from about 12 to 18 inches in total length. Under favorable conditions this pickerel may reach a weight of as much as five pounds in three years, but according to the Massachusetts Fish Commission the rate of growth appears to vary with temperature, for in a pond of cold water with plenty of food they reach a weight of but 2½ pounds in six years (Kendall, '17, p. 29).

Embody ('15, p. 227) gives the following notes on the average lengths of pickerel, very probably this species: 5 months, 4-5 inches; 1 year, 6-7 inches; 2 years, 10-12 inches. Kendall ('18, p. 581), in writing of Maine waters, says the young grow comparatively rapidly but do not reach a length of much over 2 or 3 inches the first season.

Habitat. At Oneida Lake we found Chain Pickerel in summer abundant in shallow water where there was a good cover of aquatic vegetation (Figs. 205, 207). By placing the trammel net on the lakeward side of a patch of cat-tails, pond-lilies, pond weeds or other plants growing in a few feet of water, and then disturbing the area with poles or oars we frequently caught several of these fish.

Pickerel are frequently taken at Oneida Lake by ice fishermen, and, according to testimony, most often in a few feet of water close to shore. It is said that they come to the shallows chiefly in late winter or early spring, shortly before the ice leaves, but in January, 1921, members of the Anglers Association of Onondaga County reported pickerel or pike being taken in Oneida Lake in water only a few inches deep, and very close to shore. The fish also frequents the deeper waters of the lake. On October 3, 1920, a large one, 20 inches long (Coll. No. 4200), was taken in 10 feet of water at Maple Bay, by trap net, and one was caught in 12½ feet of water north of Poddycut shoals.

Kendall ('17, p. 26) says: "The usual haunts of the pickerel are weedy streams and bays or coves of lakes. In some lakes small and medium sized pickerel occur in the shallow coves, where they lurk under lily pads or amongst the rushes and sedges. Often larger fish occur along rocky shores contiguous to deep water, especially if there are fallen trees, brush, or boulders to afford concealment. It has, also, been caught on the rocky shoals of an open lake.

"In some streams, while it is most abundant in the sluggish, dead waters where aquatic vegetation is profuse, it is not infrequently found well up in quicker water if the character of the shores or growth there provides concealment." He notes ('13, p. 23) that in winter they congregate in deeper water, and the young pickerel remain in shallow water until of considerable size.

Distribution Records. In shallow water (under 3 feet in depth) we collected the following with trammel nets: No. 469, East Potter Bay; No. 485, Fairchild Bay; Nos. 489 and 492, Three Mile Bay; No. 512, Fish Creek; No. 513, Oneida Creek; No. 542, Johnson's Bay; No. 561, Poddycut Bay; No. 567, Big Bay Creek.

The following were taken with minnow seines: No. 81, Johnson's Bay Ditch; No. 483, Fairchild Bay; No. 547, Chittenango Creek; No. 568, Big Bay; No. 569, Willow Point; Nos. 575 and 577, Three Mile Bay; No. 605, East Shaw's Bay; No. 606, Shaw's Bay; No. 142, Frederick Creek; No. 152, Shepherd Point; No. 441, Taft Bay; No. 490, Three Mile Bay; No. 510, Upper South Bay; No. 553, West Vienna; No. 603, Fairchild Bay.

The following were collected in moderately deep water (3-8 feet): No. 511, Oneida Creek; No. 4200, Maple Bay; No. 122, Shaw's Bay; No. 130, Big Bay; also the Brewerton market collection, Nos. 360 and 486.

The following were collected by Pratt and Baker in medium depth (3-10 feet): Nos. 1207, 1264, Dry Land Point; No. 1247, Muskrat Bay. No. 1233 was caught in Poddycut Bay shoals in 12½ feet of water; No. 153, found dead in Big Bay.



Fig. 211. *Dianthera* growth along north shore of Frenchman's Island. July 11, 1916.



Fig. 212. Sandy beach of Messenger Bay with windrow of May-fly carcasses at water's edge. July 5, 1916.

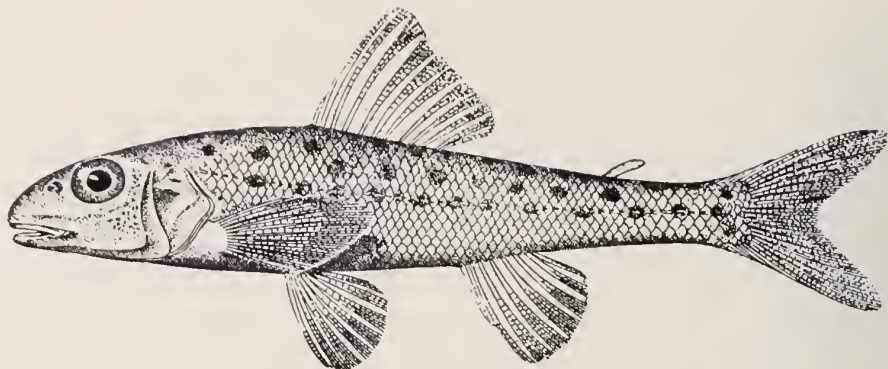


Fig. 213. Trout Perch (*Percopsis omiscomaycus*).



Fig. 214. Brook Silversides (*Labidesthes sicculus*).

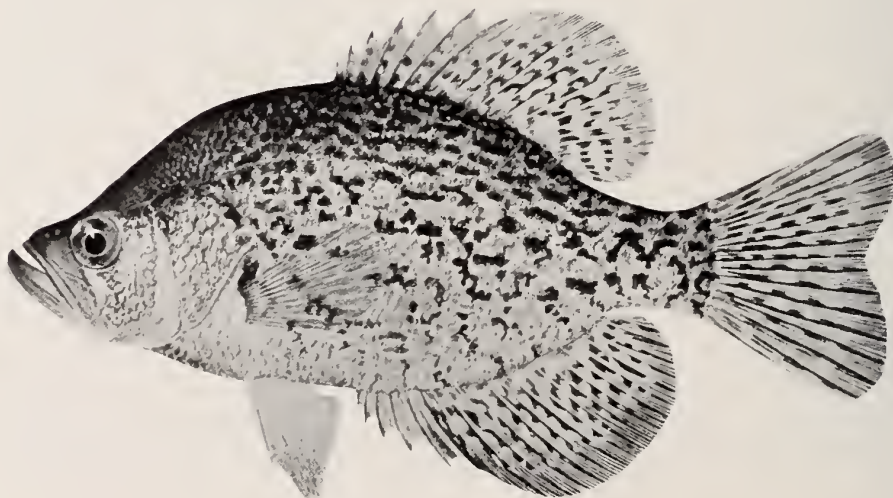


Fig. 215. Calico Bass (*Pomoxis sparoides*).

Food. This fish appears to be insectivorous when young but as it becomes larger it eats more and more of fish diet until it becomes almost entirely piscivorous; but it will readily take frogs, snakes, and almost any moving object near it, of proper size. Fifteen Chain Pickerel of mature size, taken by us from shallow water, were opened, and eleven of these contained food as shown in table following:

TABLE NO. 6. FOOD OF *Esox niger* AS REVEALED BY STOMACH EXAMINATION.

COLLECTION NUMBER	LENGTH INCHES	LOCALITY	DATE 1916	STOMACH CONTENTS
469B.....	15 $\frac{3}{4}$	East Potter Bay.....	June 28	An <i>Esox</i> 4 $\frac{1}{2}$ in. long
485D ¹	15	Fairchild Bay.....	30	Fish remains
485D ²	13	Fairchild Bay.....	30	<i>Notemigonus crysoleucas</i> 4 $\frac{1}{2}$ in. long
485D ³	13 $\frac{1}{2}$	Fairchild Bay.....	30	Head of <i>Notemigonus crysoleucas</i>
485D ⁴	11 $\frac{1}{2}$	Fairchild Bay.....	30	<i>Notropis hudsonius</i> 3 $\frac{1}{2}$ in. long
492B ¹	11 $\frac{1}{2}$	Three Mile Bay.....	July 3	Fragments of three or four fish, one <i>Boleosoma olmstedii</i>
513C.....	11	Oneida Creek.....	6	<i>Perca flavescens</i> 3 in. long
524B ¹	12	Short Point Bay.....	8	Parts of 2 small <i>Perca flavescens</i> , one 3 in. long
524B ²	15	Short Point Bay.....	8	Fish remains
542C.....	11	Johnson's Bay.....	11	<i>Catostomus commersonii</i> 4 $\frac{1}{2}$ in. long
567A.....	12 $\frac{1}{2}$	Big Bay Creek.....	17	A cyprinid

The stomachs of seven young Chain Pickerel were also examined with the following results:

TABLE NO. 7. THE FOOD OF YOUNG *Esox niger* AS REVEALED BY STOMACH EXAMINATIONS

COLLECTION NUMBER	LENGTH INCHES	LOCALITY	DATE 1916	STOMACH CONTENTS
490C ¹	3	Three Mile Bay.....	July 3	<i>Umbra limi</i>
490C ²	1 $\frac{3}{4}$	Three Mile Bay.....	3	15 fish fry; entomostracans
512D ¹	1 $\frac{3}{4}$	Fish Creek.....	6	Insect fragments
512D ²	2	Fish Creek.....	6	<i>Chironomus</i> larva; entomostracans; <i>Amphipod</i>
553E ¹	2 $\frac{3}{8}$	West Vienna stream.....	14	Fish, including 2 <i>Rhinichthys atronasus</i>
553E ²	2 $\frac{7}{8}$	West Vienna stream.....	14	Insects; amphipod
553E ³	2 $\frac{3}{4}$	West Vienna stream.....	14	Small minnow, <i>Hyborhynchus notatus</i>

Baker ('16, p. 178) examined five of these fish from Frederick Creek, a tributary of Oneida Lake at Constantia. These were all near ten inches long and had eaten collectively crawfish, *Cambarus bartoni robustus*, and one frog.

Kendall ('17, p. 27) says this species feeds mainly on other fishes, but also on frogs and other amphibians and in fact on any living thing moving in the water within reach, which it can capture and handle; that when ravenous, this pickerel does not hesitate to seize a fish at least half as large as itself or so large that

a portion of the fish may be seen protruding from the pickerel's mouth as the remainder is being digested in the stomach. In Umbagog Lake, Maine, and in New Hampshire, of the numerous Chain Pickerels examined by Kendall, those that contained any food at all usually had small suckers. Two pickerel taken from different localities in Maine had each eaten a common Bullhead, *Ameiurus nebulosus*, 4 inches long or under. Smith ('07, p. 144) says it feeds chiefly on Alewives, about Albemarle Sound, North Carolina.

There is considerable published information on the food of this species. Thoreau notes that striped snakes are eaten by this pickerel (Jordan and Evermann, '96, p. 627). The four young Chain Pickerel about 5-10 inches long examined by Baker ('18, p. 215) had eaten midges, May-flies and fish. Young Chain Pickerels $2\frac{1}{3}$ to about 4 inches long taken in Maine were found by Kendall ('13, p. 23; '17, p. 27) to have been feeding almost wholly upon aquatic larvae of insects. Three taken near Freeport, Maine (Kendall, '17, p. 27), that measured 11-15½ inches in length, also contained nothing but such larvae. Some small individuals ($2\frac{1}{2}$ -6½ inches) had also eaten fish, including sunfish, *Eupomotis gibbosus*, about an inch long; which had been taken by a pickerel $3\frac{1}{2}$ inches long. Small fingerling pickerel (l.c., p. 28) had also been eaten by larger young of their own species from about 4 to 6½ inches long. Greeley ('27, p. 62) opened two specimens from the Genesee System and found in one 11½-inch specimen, a *Notemigonus crysoleucas* about two inches long; and in another specimen $5\frac{3}{4}$ inches long, a *Eupomotis gibbosus* $\frac{3}{4}$ of an inch long.

Enemies and Disease. Kendall ('17, p. 33) considers that the habits of the pickerel expose it to more dangers than are incurred by most other kinds of fresh-water fishes. He notes that chubs (*Scmotilus bullaris*) are serious enemies of this pickerel. He has seen them feeding on the young and has caught a dozen or so of these fish, of about one-half a pound to a pound each, gorged with little pickerels two or three inches long. He mentions also seeing a young pickerel chased and driven out of water and on to a sand bar by a trout. This pickerel, about four inches long, was then secured by Kendall and used as bait by which the trout, which was about ten inches long, in turn was caught by him. The natural enemies of the pickerel as enumerated by Kendall ('18, p. 583) are frogs, other fishes as well as its own species, mergansers, grebes, loons, kingfishers and herons.

A small specimen of the species, $1\frac{3}{4}$ inches long, was found in the stomach of an *Esox lucius* $4\frac{1}{2}$ inches long, caught by us in Fish Creek, a tributary to Oneida Lake (Coll. No. 515). There is also some evidence that bullheads destroy this pickerel (Evermann and Kendall, '96, p. 597; Kendall, '17, p. 33).

The eggs and fry of the Chain Pickerel are also subject to serious dangers, according to Kendall ('17, p. 33) who says: "The character of the egg masses and their exposed situation in shallow water subject them to the ravages of other fishes, such as suckers, chubs, perch, etc., as well as reptiles and waterfowl.

"A Superintendent of one of the Pennsylvania hatcheries wrote that he estimated that fully 10 per cent of eggs deposited are devoured by other fishes before they are hatched and that storms sometimes sweep the eggs from where they are deposited and float them ashore, where they rot. He stated that he had seen hundreds of millions of eggs thus washed ashore and lost. But the destruction does

not end there, for the fry from the time it is hatched is the common prey not only of various fishes, including its own kind, but also of reptiles, birds and other animals."

Wilson ('92, p. 718) found *Argulus versicolor* Wilson attacking the Chain Pickerel, and some cestodes also have been found in it. According to Stiles and Hassall ('12, p. 59), *Proteocephalus nematosoma* (Leidy) was found in the stomach of this species; and LaRue ('14, p. 298) notes the occurrence of *P. pinguis* LaRue.

Two trematodes have been recorded from the Chain Pickerel: *Distoma tereticolle* (Rudolph), according to Stiles and Hassall ('08, p. 225); and *Azygia longa* (Leidy), according to Manter ('26, p. 72) and Ward ('10, p. 1181). Pratt ('23, p. 65) found a trematode, *Azygia*, in the stomach of each of two pickerel of this species; a third one contained *Neoechinorhynchus* and *Acanthocephalus*. Van Cleave ('23) records *Echinorhynchus thecatus* Linton (p. 79) and *Neoechinorhynchus cylindratus* (Van Cleave) (p. 80) from Oneida Lake specimens of this pickerel.

Economic Relations. The flesh of the Chain Pickerel taken from cold water and properly cooked when fresh makes a table delicacy, according to Kendall ('17, p. 30), although it has many small bones. With many people this Pickerel is not highly relished, which may be due to improper preparation. In some bodies of water the flesh has a "weedy flavor" (Nash, '08, p. 68). Estimates of the table value of this fish are therefore various, by some it is relished highly, by others considered inferior.

The Chain Pickerel has a reputation for destroying trout. Kendall ('17, p. 34) in discussing this point, says that like other members of the family, it is an extremely voracious and destructive fish, but is seldom found gorged with food, and during most of the year it was found by Kendall and Goldsborough ('08, p. 60) to resort to waters uncongenial to trout, and at all times preferring such waters. They consider the harm done by pickerel to be overestimated. They say: "The injurious effect of pickerel upon trout and salmon is more often indirect than direct, especially when it appears in congenial waters where trout or salmon are barely maintaining themselves or are decreasing. The indirect influence is upon the food supply, and this reverts upon the pickerel itself ultimately."

Angling. As a game fish it is well known and is much sought in Oneida Lake in winter by anglers who fish through the ice, as well as at warmer seasons when it is caught by both trolling and still-fishing. Kendall ('17, p. 35) notes that its actions on the hook are much like those of the trout, and in order to appreciate the gameness of the fish he suggests using a light casting rod, a slender bait rod, or even a fly rod, instead of a long, stiff pole, and then playing the fish. Kendall and Goldsborough ('08, p. 60) say: "As a game fish the pickerel is highly esteemed by many. It will not always bite, the most attractive lure being often regarded with contempt and immobility. Then, again, it will voraciously strike at anything offered it. When hooked it seldom leaps from the water like a bass or salmon, but fights vigorously and rushes and tears about until, wearied with the struggle, it yields to the landing net or gaff. There are many methods of fishing for the pickerel. It is trolled for successfully with any of the various artificial baits,

such as phantoms, spoons, and spinners, which may be used with or without bait. Casting and 'skittering' is perhaps the favorite method with sportsmen, who use a long rod or pole and casting spoon or fish or frog bait. In this method the bait may be a whole shiner or a strip from the white belly of any fish; a whole small frog, or the skinned leg of a large one, or at times a piece of pork, red flannel, or white cloth, when nothing better is available. In fishing with artificial lures of any kind the pickerel should be struck the instant it bites; with natural bait the line should be slackened and the fish should be allowed to retain the bait until it has swallowed it or got it well into the mouth, as it usually takes the bait crosswise, then stops and works it round endwise to swallow it, and does not get the hook into its mouth until it has begun to swallow the bait.

"Still fishing with live shiner or frog is another method suitable to anglers with less strenuous dispositions. In still fishing the shiner should be hooked through the back just in front of the back fin with the point of the hook toward the head, with care not to injure spine of the fish. A frog should be hooked through the tip of the lower jaw and nose. Fishing through the ice with set lines and hand lines is a common pastime or occupation in many localities. The set lines are used with a 'tip-up' flag showing when there is a bite. Hand-line fishing in winter is much the same as still fishing in summer."

In small bodies of water this fish may have its numbers seriously depleted in a short time by fishing for it through the ice, for at times all seem to gather at one place and take the bait voraciously (Kendall, '13, p. 23; '17, p. 33; '18, p. 584).

References. Baker, '16, '18; Bean, '03; Embury, '15, '18; Evermann and Kendall, '96; Goldberger, '11; Greeley, '27; Jordan and Evermann, '96; Kendall, '13, '17, '18; Kendall and Goldsborough, '08; LaRue, '14; Leidy, '04; Nash, '08; Pratt, '23; Ryder, '87; Smith, '07; Stiles and Hassall, '12; Van Cleave, '23; Ward, '10, '11, '18; Wilson, '92; Wright and Allen, '13.

Esox lucius Linnaeus. COMMON PIKE, LAKE PICKEREL. This species is common in Oneida Lake but not so abundant as the Chain Pickerel. It appears to attain a large size there. Fishermen recognize two species of pickerel in the lake and this larger form is called by them the "Common Pike, or Laker," and sometimes the "Spotted Pickerel," in distinction from the reticulated Chain Pickerel. Mr. George H. Travis of Cleveland told us that these pike are sometimes taken at the present time weighing from 15-20 pounds, and that there are quite a few caught that weigh around eight pounds. About thirty-five years ago one weighing 25 pounds was taken in Oneida Lake.

Breeding Habits and Life History. This species breeds in early spring, shortly after the ice leaves, or even in winter (Bean, '03, p. 301). According to Embury ('18, p. 253), the pike spawn at the southern end of Cayuga Lake a week or more after they begin to enter the marshes, which takes place at the time the ice leaves (about the middle of March). Allen ('14, p. 58) also notes their running at Ithaca with the disappearance of the ice, and while the inlet of Cayuga Lake is still full of floating ice the Pike are along the shore trying to enter the marshes, and here they spawn in large numbers during March and April. Embury notes that temperature seems to determine the spawning time because the act occurs when the water approaches 8° C. (46.4° F.). They appear to begin spawning a



Fig. 216. Beach at east end of the lake, showing wave-formed pools. Sept. 9, 1927.



Fig. 217. Wave-formed pools at Sylvan Beach, which contain many small land-locked fishes of the lake. Sept. 9, 1927.



Fig. 218. Shore pond at Sylvan Beach with land-locked fish. Sept. 9, 1927.



Fig. 219. Several thousand minnows including *Notropis atherinoides*, *N. rubrifrons* and *N. dorsalis* taken in one haul of the seine. Sept. 9, 1927.

little earlier than the Chain Pickerel, but the two species may be spawning on the same area at the same time. Wright and Allen ('13, p. 5) give the breeding time as March to May. Hankinson ('08, p. 209) found them spawning in southern Michigan in early April. In Illinois Forbes and Richardson ('09, p. 208) note its breeding in March.

At Oneida Lake the fish very probably spawn in situations similar to those used by the Chain Pickerel. Forbes and Richardson (l.c.) say they use shallow places upon meadows and banks which have been overflowed. Wright and Allen ('13, p. 5) consider swampy streams, shallow overflows, and ditches to be the breeding habitats.

In spawning behavior this species is practically identical with the Chain Pickerel, according to Embury ('18, p. 253). The eggs are about one-eighth inch in diameter, and the period of hatching varies from fourteen to thirty days. The female is said to be larger than the male, and the fish breed at the age of three years (Bean, '03, p. 301). According to Forbes and Richardson ('09, p. 208), a single female may deposit as many as a hundred thousand eggs, and the young hatch in about fourteen days and may reach a length of a foot by the end of the first year. According to Bean ('03, p. 301), it will increase in weight from two to three pounds yearly. This pickerel reaches a large size, the largest on record being, according to Nichols and Heilner ('20, p. 1), thirty-two pounds and seven ounces. Preble ('08, p. 513), however, says that it reaches a weight of thirty-five pounds or more in the Mackenzie Valley. One weighing fourteen pounds and having a length of thirty-eight inches was taken from Oneida Lake, November 30, 1915. A photograph of this was obtained. Embury ('15, p. 227) records the following data on the growth of the Pike: at age of five months, five to six inches long; one year, eight to eleven inches; two years, fourteen to sixteen inches.

Habitat. The fourteen Lake Pickerel caught by us in Oneida Lake were all taken from among water vegetation near shore, in water under four feet deep and in the summer. Marginal cat-tail and other plant patches are very probably favorable lurking places for this fish in Oneida Lake, at least in summer. Kendall ('17, p. 19) notes such a summer habit and habitat when he says: "The pike chooses its spring and summer haunts by preference in shallow inlets with weedy bottoms and shores overgrown with reeds and rushes." He says that towards autumn this fish betakes itself to precipitous, stony shores, which it again forsakes when winter is at hand and most of the fish then return to their summer stations, but the larger ones seem to go to deep water since they are seldom caught during the winter in shallow water. Forbes and Richardson ('09, p. 208), writing of the species in Illinois, say that it prefers clean, clear cool water with a sluggish current. In this it remains generally quiet by day. Preble ('08, p. 513) writes of its extreme abundance and large size in the Mackenzie Valley and says it is much less common in the muddy rivers than in the clear lakes and that its favorite haunts are the pools at the foot of falls or rapids. Bensley ('15, p. 34) says that this fish inhabits weedy swamps and channels, where it lurks among the weeds, darting forth from time to time to capture small fishes. Reighard ('15, p. 229) records its capture at all depths between four and forty-five feet in Douglas Lake, Michigan, and says that it appears not to go below the thermocline in midsummer, but at other seasons it is possible that it goes to deeper water.

In the spring, as noted under discussion of life history, this fish comes to shallow water as a preliminary to spawning (Hankinson, '08, p. 209). The young linger in pools of the marshy breeding grounds (Allen, '13, p. 58). Dymond '26, p. 73) says that in Lake Nipigon it resorts to deep water, 60-100 feet, in summer.

Food. A few Lake Pickerel caught in Oneida Lake have been opened to determine the nature of their food. The following table shows the food of eight specimens.

TABLE NO. 8. FOOD OF THREE ADULT AND FIVE YOUNG *Esox lucius* AS REVEALED BY STOMACH EXAMINATIONS

COLLECTION NUMBER	LENGTH INCHES	LOCALITY ONEIDA LAKE	DATE 1916	STOMACH OR INTESTINE CONTENTS
360-1.....	12	Market specimen.....	About May 1	Cestodes (numerous). No food
360-2.....	16	Market specimen.....	About May 1	Cestodes (numerous). No food
524C1.....	17	Short Point Bay, Oneida Lake	July 8	1 <i>Perca flavescens</i> about 6 in. long and 1 <i>Catostomus commersoni</i> about 4 in. long
475F1.....	1 $\frac{3}{4}$	Lower South Bay.....	June 29	About a dozen Cladocerans
475F2.....	4	Lower South Bay.....	June 29	A caddice fly pupa, minnow fragments
515B.....	4 $\frac{1}{2}$	Fish Creek.....	July 6	1 <i>Esox niger</i> 1 $\frac{3}{4}$ in. long
517K1.....	4 $\frac{1}{4}$	Sylvan Beach.....	July 6	1 <i>Boleosoma olmstedii</i>
517K2.....	4	Sylvan Beach.....	July 6	1 <i>Notropis atherinoides</i>
				Insect wing fragments and other material

Kendall ('17, p. 19) says that the Pike is undoubtedly the most voracious among the fresh-water fishes and that it devours indiscriminately other fishes, young waterfowl, small mammals and carrion. And further: "From the dense bed of grass or rushes, where it usually passes the day in stationary watch, it pounces with the speed of an arrow on its unwary victims. It almost always seizes its prey crosswise and retains its hold until the latter is dead or so exhausted as to desist from all struggles. Then the pike turns the prize in its jaws till the head points toward the interior of its mouth and commences its meal."

Forbes and Richardson ('09, p. 208) say of its food and feeding: "It is a strong and active swimmer, extremely voracious, and with senses remarkably acute. It launches itself like an arrow upon its prey, seldom missing its aim, and fighting courageously with others of its kind. It is purely carnivorous, its food consisting of fishes among which we have noticed sunfish and black bass, together with frogs, crawfishes, and the larger insects. Mice, reptiles, and young ducks have been reported by various authors to have been taken from the stomachs of pike."

Pearse ('18, p. 258) examined the food of thirty-six individuals of this species, measuring from near two inches to about thirty-five inches and averaging about a foot in length. 84% of the food was fish; about 6 $\frac{1}{2}$ % insect material and the rest largely entomostracans, leeches, and mollusks. The small ones eat invertebrates while the adults live nearly altogether on fish. Hankinson ('08,

p. 209) found them eating Perch at Walnut Lake. Six of the nine caught had eaten Perch and nothing else, and one had eaten three darters. In the Whitefish Point region he found a Mud Minnow, a leech, and a sculpin in stomachs of small pike ('16a, p. 148). Reighard ('15, p. 229), in treating of this species in Douglas Lake, Michigan, says that seven of the twenty-two stomachs examined contained the remains of fish, while the rest were empty; and he found no evidence that in midsummer, the time of the investigations, the Douglas Lake Pike took other food than fish, and he notes that in two cases Perch, about four inches long, were found in Pike stomachs. Henshall ('19, p. 139) says it feeds on fish, frogs and water snakes. Wilson ('20, p. 226) found an adult of this species eating dragon-fly nymphs. Marshall and Gilbert ('05, p. 517) found minnows in seventeen of twenty-two specimens of *Esox lucius*; also a *Lepomis incisor* in one, a small *Esox* in one, crawfish in one and leeches in one. But two of the Pike contained food other than fish. Needham ('22, p. 30) says the Northern Pike in Lake George is undoubtedly the most active and exclusive fish eater there, and he notes that records of examinations extending over many years at Cayuga Lake, N. Y., show them to be almost exclusively fish eaters. Clemens ('24, p. 124) reveals the character of the food of twenty-three specimens of *Esox lucius* from Lake Nipigon, of size ranging from $3\frac{1}{3}$ inches to 40 inches. All but two had fish in their stomachs, these being of various species, but soft-rayed forms were most often represented. Two spiny-rayed fish, Perch (*P. flavescens*) and Pike Perch (*S. vitreum*), were present. The two specimens that contained no fish remains had eaten a short tailed shrew (*Blarina brevicauda*), in one case, and a leech in the other. Dymond ('26, p. 73) gives a general conclusion as to the food of *Esox lucius* in Lake Nipigon. He says: "Here it feeds on the smaller fish inhabiting such situations, but does not scorn anything in the way of animal food that comes within its reach, as is attested by the variety of creatures that have been found in its stomach."

The food of twenty-four Pike from Green Lake, Wisconsin, is described by Pearse ('21, p. 263). These Pike ranged in size from about 4 inches to about 26 inches. Fish, principally minnows, had been eaten by nearly all; but Perch remains were found in one. Plants and ostracods were present in small amounts.

Distribution Records. We made the following collections of the species in shallow water (three feet and under): No. 434, Norcross Point; No. 475, Long Point Peninsula; No. 502, bay west of Lewis Point; Nos. 515 and 516, Fish Creek; No. 517, Sylvan Beach; No. 524, Short Point Bay.

We obtained from the Brewerton fish market Nos. 360 and 628B.

Enemies and Disease. The Pike appear to have few enemies other than man, who shoots them at their spawning time in early spring and captures them by hook and in other ways. Predacious animals, also, undoubtedly capture them. Fowler ('13, p. 13) cites an instance in Europe where an Osprey skeleton was found attached to the back of a large *Esox lucius* and says that similar stories of other European birds, as Sea Eagles, have been told.

The fish appears to be rather heavily infested with parasitic worms, and sometimes there is a prejudice against using it for food on account of its "wormy flesh" (Hankinson, '16, p. 149). Two market fish, said to have come from Oneida Lake,

as noted in the table above, had many cestodes in their stomachs. Marshall and Gilbert ('05, p. 518) examined thirty-five of this species from Lake Mendota, Wisconsin, taken during April, May and November. Every fish contained some parasites, but those taken in spring were much freer from them than were those caught in November. Trematodes were found infesting the mouth, gullet and stomach. These were nearly all *Azygia tereticolle* (Leidy). Other trematodes that have been found in *Esox lucius* in North America are *Phyllodistomum folium* (Olfers), recorded by Stafford ('04, p. 492); and *Centrovarium lobates* (MacCallum) (see Ward, '18, p. 401, and Stafford, '04, p. 493). LaRue ('26, p. 285, and Butler, '19, p. 116) found larval trematodes in the eyes of *Esox lucius* taken in Douglas Lake, Michigan. The cestode *Protococephalus pinguis* LaRue (Ward, '18, p. 437) is found in the Pike; also a nematode, *Neocchiuorhynchus tenellus* (Van Cleave, l.c., p. 546). Wilson ('16, p. 339) notes two copepod parasites from this fish, *Argulus versicolor* Wilson, and *Ergasilus*; and also glochidia of the mussel *Quadrula plicata*, infesting the gills of the Pike. Needham ('22, p. 65) notes their decrease in number through disease in Lake George, and Sibley ('22, p. 77) mentions the same fact, with the further information that the epidemic reached its height in 1919, when the number of dead pike floating on the surface of the lake was very great.

Economic Relations. The relative importance of the Pike as a food and game fish in our waters is a subject on which anglers and fishermen disagree, and is surely worth a special investigation. Like the Chain Pickerel, it destroys many other fish, but on account of its larger size and its wider geographical distribution, it is the more important destroyer of fish of the two. In Oneida Lake, however, it is not nearly so abundant as the Chain Pickerel and hence is of less economic importance there. In bodies of water where suckers, large minnows and other "rough fish" thrive and where black bass or trout do not find suitable conditions, the Pike may be a very desirable species, and bodies of water containing them have attractions for anglers; but in trout streams and other waters where better game fish thrive, the species may be positively detrimental. Kendall ('24, p. 236) stresses the importance of studying the species in water where it is found, before condemning it, since it may have beneficial or harmful relations in different regions depending upon the conditions in each. Embury ('22, p. 16) considers large pike detrimental to angling in Cayuga Lake, because it destroys smaller fish of its own species as well as of other species, particularly the Yellow Perch. He advises permitting commercial fishermen to remove the large fish when advisable to do so. Before introducing Pike in any region, therefore, much attention should be given to its probable effect on the fish already present.

The flesh of the Pike is firm and palatable, but not often highly relished. It is better for food during the cold seasons of the year. Kendall ('17, p. 24) notes that it can be kept for a long time in a salted or dried condition.

Angling. When hooked the Pike is a powerful and persistent fighter and on this account it is much sought by anglers. Trolling is the usual method employed in taking it. Spoon hooks and other artificial baits, minnows or other small fish, especially those with silvery sides, and frogs are used in trolling in shallow, marginal waters where this fish commonly rests, especially about water lilies or other



Fig. 220. Scene at mouth of small tributary creek of Oneida Lake at West Vienna.
July 14, 1916.



Fig. 221. Douglas Creek. View upstream near the lake. June 22, 1916.



Fig. 222. Chittenango Creek at the Protector's Camp, looking downstream near the lake. July 12, 1916.



Fig. 223. Chittenango Creek at Bridgeport. View during the spawning season of Pike Perch. April 8, 1921.

plants, watching for prey. Sometimes they are taken by still-fishing in the deep waters of lakes and streams. A large, lively, silver-sided shiner appears more apt to entice them than do other baits. Like the Chain Pickerel, they are taken through the ice. Tip-up fishermen frequently get them.

References. Allen, '14; Bean, '03; Bensley, '15; Clemens, '24; Dymond, '26; Embury, '15, '22; Forbes and Richardson, '09; Fowler, '13; Greeley, '27; Hankinson, '08; Henshall, '19; Kendall, '17, '24; Marshall and Gilbert, '05; Needham, '22; Nichols and Heilner, '20; Pearse, '18, '21; Preble, '08; Reighard, '15; Sibley, '22; Stafford, '04; Ward, '18; Wilson, '16; Wright and Allen, '13.

Anguilla rostrata (LeSueur). EEL. This is an important market fish in the lake whence more than 100 tons have been taken in a single year. It is the only fish in the lake, and for that matter, the only known fish, that spends most of its life in fresh water and then migrates to the sea to breed, and, furthermore, breeds exclusively in the sea. No fish has a more remarkable and interesting life history, and about few if any others are there so many erroneous ideas and superstitions current.

Breeding Habits and Life History. Information on the life history of the Eel is summarized by A. Meek ('16, pp. 148-159), Smith ('13) and Eigenmann ('01) and Schmidt ('25). Meek ('16, p. 149) says: "The eels spawn in the deep waters of the ocean, the fresh-water eels with approaching maturity migrating from the fresh waters of western Europe and eastern America far into the Atlantic for the purpose; the eggs give rise to larvae, called Leptocephali, and the larvae drift in the ocean currents towards the coasts of the Atlantic, where they change into elvers; the elvers migrate up the rivers, and the eels spend many years feeding and growing until maturity impels them to return to the place of their origin."

The spawning place had been unknown till Johs. Schmidt made public his studies, based on extensive observations as to the distribution of the larvae of both the European (*Anguilla vulgaris*) and the American Eel. The breeding place appears to be between Bermuda and the West Indies, about 22°-30° North latitude and between 48° and 65° West longitude, for the European Eel (Schmidt, '25, pp. 296, 308), and for the American Eel (l.c., pp. 297, 308) an area more to the west; but there is great overlapping of the ranges of the two species (p. 308). The breeding range of the American Eel appears to be to the north of the West Indies, with its center to the west and south of the breeding area of the European species. There is a possibility of the breeding place varying from year to year (l.c., p. 296). The time of spawning for the European Eel (p. 297) begins in late winter and early spring and lasts to well on in the summer. Schmidt considers it probable that the American species breeds earlier (p. 306). The larvae are true pelagic organisms (p. 300). The European Eel spends about three years in the larval stage before completing the metamorphosis into the adult form (p. 303), while with the American Eel the time is much shorter, about a year (p. 309). Meek ('16, pp. 149, 154) further informs us concerning the life history of American and the European Eel, as follows: "The small Leptocephali are caught in the current of the Gulf Stream and carried towards the coast over an area extending from Greenland to northern Africa. Feeding is apparently confined to the early portion of the

larval life, for the advanced larvae which have been examined have been found to contain no food . . . and this lasts until they receive the impulse which will convert them into the young eel stage. . . . During their drift in the Atlantic current the larvae increase from a size of 6 to over 8 cm before they undergo the metamorphosis into the eel condition. It is plain, therefore, that during their oceanic existence they are able to retain their larval condition, and that it is when they are carried into the neighborhood of the coast that the change occurs. It is possible, then, that the incentive to the change is the contact with water of lower salinity. . . . When the larvae arrive at about the 500 fathoms line the metamorphosis takes place; but as has been seen, the larval stage is retained in the case of the young larvae entering the Mediterranean. The resulting glass eels, so called on account of their transparency, appear in the North Sea from November to May, mainly from December to February. . . . In the rivers of the south of the North Sea the ascent begins in February and continues to June or July. . . . The ascent of the elvers in the rivers is a well-known annual feature. The vast crowds moving upwards in a compact column following each bank of the river, and their persistent efforts to reach the upper parts of the rivers, streams, lakes, and ponds have been often observed and recorded." It has also been observed that the migration is strongest at night, and that it is liable to interruption by lights and even at full moon. (Cox, '16, pp. 115-118).

Very little indeed is recorded about the migration of American Eels into our streams. Tracy ('10, p. 70) gives the following for Rhode Island: "Migration of young 2 to 3 inches long up Taunton, Warren, and Kickamuit rivers takes place from about April 15 to May 15." Smith ('13, p. 1142) states: "The migration, coming in late winter or spring, may last for a few days or several weeks in a given stream, and the young, closely skirting the shores, may be in a practically unbroken column during the entire period. All large eels are females, and only females enter conspicuously into the market supplies in either America or Europe. Any eel over 40 centimeters (16 inches) is almost certain to be female. All eels found in the headwaters of large streams are females. The males remain in the lower courses of rivers and as a rule do not go above the tidewater." Fowler ('06, p. 120) remarks: "In the Delaware I have seen thousands of small eels during July and August wriggling along the mud and flats as the tide ebbed out. They are about 3 inches in length." (Cf. Fowler, '08, pp. 139-140.) Meek ('16, p. 157) further states that "The freshwater life is characterized by a diurnal change from relative quiescence during the day to relative activity during the night, and the seasonal one from complete or partial hibernation in winter to the active feeding habits of summer."

When the Eels mature in streams, at an age between $6\frac{1}{2}$ to $8\frac{1}{2}$ years (cf. A. Meek, '16, p. 156), they begin their journey to the sea, and it is during this journey that so many are caught in traps. Meek ('16, pp. 155, 156) says: "When the impulse of approaching maturity comes to them, eels undergo a remarkable change. They gradually cease to feed; the underpart of the body becomes clearer and whiter, the dorsal region turns darker, and the eyes are enlarged. Silver eels as they are then called, have long been known in Europe and in America and were believed to be a distinct species."

The Oneida Lake fishermen report (Adams and Hankinson, '16, p. 160) that the largest catches of Eels are taken during July and August, in the outlet of the lake in Oneida River at Caughdenoy, following an east wind blowing toward the outlet. This suggests that the Eels go with the wind and the current, probably as a response to the surface current caused by the wind. Peterson ('01, p. 20) says of the silver eels in Danish waters: "I have mentioned that the west wind drives the eels into the eastern points of the Great Belt, but an east wind, which is much rarer, can when it comes, drive them in the opposite way." Petersen ('08) has also shown that light has a powerful influence upon the migration of silver eels. It seems probable that migration takes place largely near the surface. Thus he (i.e., '08, p. 6) says: "Unless it be considered that the eels migrate as a rule in the upper layers, I do not understand how the surface currents, the wind, and the moonlight can have so great an influence on the migrations of the eels as they actually have." These observations on the wind and the current thus harmonizes with those of Oneida Lake.

The State law requires that eel weirs leave on the sides an open area 12 feet wide for the passage of boats, but a strip 30 feet wide is left at Caughdenoy. At Caughdenoy the canal runs parallel to the river and when the gates are up, as in the summer of 1917, a strong current flows down the canal. To this strong current is attributed the small catches of Eels in 1917, as it is supposed to lead the Eels down the canal rather than by the feebler current over the dam to the eel weirs. These two conditions permit Eels to pass around the weirs; but Petersen's experience as to light suggests that these weirs might be so placed as to stop their passage through these boat channels and to overcome the tendency of the stronger canal current and thus increase the catch possibly at slight expense. Experiments should be made to test this idea, because of its scientific and economic importance. "It has been observed," remarks Meek ('16, p. 157), "that the silver eels frequently descend the rivers massed together in balls, and it is probable that this indicates how they are associated during spawning. It is generally believed that the migration takes place only once in the life of the eel." A case is recorded (Meek, i.e., p. 156) of an Eel having been kept in captivity for 37 years. Old female Eels reach the length of five to six feet.

Mr. J. D. Black informs us that in Oneida Lake during about the first two weeks in June the Eels are found on gravel and stone bottom, and can be approached so easily as to give the impression that they are blind. Mr. W. A. Dence of the Roosevelt Station Staff has likewise observed eels in shallow water at night, during early June, along the shore from Shepherds Point to Muskrat Bay. Following this period, during the May-fly or eel-fly season, they are found on eel-grass, where Mr. Black has seen them in spiral masses and tangled balls, varying in size from a few individuals to balls larger than a half-bushel measure.

Habitat. It has been shown that Eels evidently breed in the open sea far from land, and spend two or three years of their early life there. They then ascend streams, the males tending to remain in the lower waters and the females to ascent to the headwaters. In fresh water they live in a great variety of conditions and are very hardy. They can live in warmer waters than many other fishes can endure. After many years of life in fresh water they return to the sea to

breed and are supposed to die there. The Eel is thus not only remarkable for its great changes of habitat with age, but also for enduring a great variety of conditions in fresh water. There are many reports of its occurrence on land. Mr. W. H. Weston, Division Chief of the N. Y. State Conservation Commission, and Mr. J. D. Black, Protector, inform us that while patrolling, late in May, the lower parts of Chittenango Creek they saw by the aid of a lantern many Eels crawling about in the swamp. Their attention was attracted to the place by a splashing of the water, and strange sounds. Several times they saw Eels crawling about on the north bank, among the grass and weeds near the mouth of the Creek, on dark, rainy nights; and Mr. Black saw them in large numbers on the overflowed meadows opposite the protectors' camp on Chittenango Creek, during a day and one night late in May.

Kendall and Goldsborough ('08, p. 37) say: "In lakes during the daytime the Eel remains in rather deep water, approaching the shore at night to feed. Specimens are caught in these lakes in water from 30 to 60 feet deep. In winter, in cold localities like New England, the Eel burrows in soft mud, and there hibernates." Fowler ('06, p. 120) states that at Cape May, "They generally burrow six or eight inches down, sometimes a little further, and often they become more or less quiet or dormant and are speared. They appear to remain concealed according to temperature and never burrow in warm weather." Mitchill ('15, p. 360) notes that in winter Eels lie covered in the mud and are taken in great numbers by spearing.

In Oneida Lake there is considerable fishing with "tip ups" through the ice, but we have heard of no Eels being caught by this method, although we have made inquiries of several experienced men. So far as we know Eels are not speared in this lake while hibernating in the mud, as is reported to be done in some other places.

Food. Meek ('16, pp. 154-155) summarizes the food of eels as follows: "During the period of their life in fresh water Eels feed on all kinds of animal food and garbage, even on one another, fish and fish ova, insect larvae, crawfish, frogs, water fowl, water rats, aquatic plants, and other vegetable foods. They are said even to leave the ponds and rivers and canals and streams to feed on plants in the fields. At all events, they have repeatedly been seen on land wriggling their way through wet grass. They are most active at night, and it is then the feeding is mainly done and the migrations from ponds and streams take place." Dr. Jordan ('05, Vol. 2, p. 147) gives the following quotation from Ballou, remarking that Eels are among the most voracious of carnivorous fishes. "They eat most inland fishes, except the garfish and the chub. Investigation of six hundred stomachs by Oswego fishermen showed that the latter bony fish never had a place in their bill of fare. They are particularly fond of game-fishes, and show the delicate taste of a connoisseur in their selection from choice trout, bass, pickerel, and shad. They fear not to attack any object when disposed. . . . On their hunting excursions they overturn huge and small stones alike, working for hours if necessary, beneath which they find species of shrimp and crawfish, of which they are exceedingly fond." The stomach of an Eel (No. 1524) in the Roosevelt Station collection from Otisco Lake, taken at night, July 16, 1917, with hook and



Fig. 224. Eel weirs at Caughdenoy in Oneida River. September, 1915.



Fig. 225. Another view of Eel weir at Caughdenoy. July 29, 1917.



Fig. 226. Stretching and drying boards for Eel skins. Photograph also shows dried skins and rendered oil.



Fig. 227. Eel cribs on shore of Oneida River.

line, contains among the recognizable fragments in addition to the earthworm bait, fragments of crawfish (*Cambarus*) appendages, and 2 gastroliths. The stomach also contained a hook and about a foot of fish line, souvenirs of an earlier experience.

Kendall and Goldsborough ('08, p. 37) state: "The Eel subsists upon almost any kind of animal food. It can and does catch live fish for itself and feeds also upon worms, insect larvae, small mollusks, and not infrequently upon fish eggs when they are obtainable." Fowler ('13, p. 15) reports that in Europe Eels have been known to capture water birds. Warren ('97, p. 25) writes that Eels destroy young Clapper Rails. Mr. Morris Shell of Brewerton, an experienced fisherman, informs us that late in May and June, when bullfrog tadpoles are in the swamps, Eels abound there and are said to feed on them. He says that it is only at this season that the Eels frequent the swamps.

Distribution Records. Previous mention has been made of a large dead Eel, bearing a Lamprey scar, which we found near Brewerton. Just previous to finding this we had been assured by an experienced fisherman that Eels were not attacked by Lampreys. Our specimens (Nos. 106, 108, 125, 352, 486, 601) were largely taken by fishermen, but one (No. 488) was taken in a trammel net set in 4 to 5 feet of water, near shore, July 3, 1916. Two large Eels (No. 150) from Oneida Lake were on exhibition at the State Fair in September, 1915. These, after preservation in formalin, measured $35\frac{1}{2}$ and $37\frac{7}{8}$ inches in length respectively. The smallest specimens which we have procured (No. 601) are $18\frac{5}{8}$, $18\frac{7}{8}$ and (No. 106) $19\frac{3}{4}$ inches long. A live Eel was seen in the water at Shaw's Bay on July 26, 1916, in water about three feet deep.

Enemies and Disease. Adult Eels appear to be well able to take care of themselves. Ballou assures us that a fish is yet to be reported that has taken a full grown Eel as food. Young Eels, however, do not fare as well, for he remarks: "Mr. Sawyer describes the operation of the pickerel darting through a long column of young Eels open-mouthed and devouring vast numbers of them." Wilson found small Eels in the stomach of a Great Blue Heron (*Ardea herodias*). Fowler ('13, p. 10) records an Eel 10 inches long from the stomach of the American Merganser (*Mergus americanus*). The Eel is recorded also from the stomach of the Bald Eagle (*Haliaeetus leucocephalus*) (Fisher, '93, p. 101); it has been taken from the stomach of a Double-crested Cormorant (*Phalacrocorax auritus*), according to Taverner ('15, pp. 11, 15); and Bartsch ('03, p. 107) records "several small Eels" among the food of the Black-crowned Night Heron (*Nycticorax nycticorax naevius*). Rhoads ('03, p. 158) lists the Eel in the food of the Otter, *Lutra canadensis* (Schreber), and Warren ('97, p. 311) gives circumstantial evidence that an Eel was taken from a spring by a Mink (*Putorius vison*). Evermann and Clark ('20, Vol. 1, p. 584) found Eels in the stomach of the water snake (*Natrix sipedon*).

Many animal parasites of the Eel are known, including the following:

TREMATODES OR FLUKES

Distoma lobates MacCallum. MacCallum, '95.

Distomum nodulosum Froelich. MacCallum (l.c.).

- Distomum opacum* Ward. MacCallum, '95. In *Stizostedion vitreum* (cf. Ward, '12, p. 234).
Distomum grandiporum Rudolphi. Linton, '01, p. 436.
Distomum vitellosum Linton. Linton (l.c.)
Distomum sp. Linton, '01, p. 436.
Brachyphallus affinis Looss. Stiles and Hassall, '08, p. 386.
Azygia sebago Ward. Ward, '10, pp. 1182, 1184; in the stomach.

CESTODES OR TAPEWORMS

- Taenia dilatata* Linton. Linton, '01, p. 435; '97, p. 425.
Rhynchobothrium heterospine Linton. Linton, '01, p. 436.
Rhynchobothrium imparispine Linton. Linton, '01, p. 436; '00, pp. 268, 276.
Rhynchobothrium bulbifer Linton. Linton, '01, p. 436.
Rhynchobothrium. Cysts. Linton (l.c.).
Scolex polymorphus Rudolphi. Linton, '05, pp. 332, 351.
Dibothrium larva. Linton (l.c., p. 351).
Proteocephalus macrocephalus (Creplin). LaRue, '14, pp. 130, 296, 302.

NEMATODES

- Heterakis foveolata* Rudolphi. Linton, '05, p. 351.
Filaria quadrituberculata Leidy. Leidy, '04, p. 103.
Filaria rubra Leidy. Bean, '07, p. 125.
Ascaris sp. Linton, '01, p. 435.

ACANTHOCEPHALA

- Echinorhynchus globulosus* Rudolphi. Linton, '01, p. 435.
Echinorhynchus agilis Rudolphi. Linton, '01, p. 435.

A larval river-mussel (*Quadrula heros*) on the Eel has been reported by Howard ('14, p. 34); and *Arcidens confragosus* by Wilson ('16, p. 338). The Eel is infested also with a parasitic copepod or fish louse, *Argulus laticauda* Smith (Wilson, '02, pp. 648, 705).

In Europe a bacterial disease, the red plague, is caused in the trout by *Bacillus anguillarum* Canestrini. (See Bean, '07, pp. 139-142; Hofer, '06, pp. 15-19.) In captivity the Eels are said by Bean ('02, p. 293) to be "particularly liable to attacks of fungus, which do not always yield to treatment with salt or brackish water but the parasite can be overcome by placing the Eel in a poorly lighted tank."

Economic Relations. We are indebted to Mr. C. F. Davison and Mr. H. N. Coville of Brewerton, for the following items concerning their Eel fishing operations. Eels are taken in various parts of the lake, but the main catch is made at Caughdenoy, four miles down the Oneida River, just below the large dam which controls the level of Oneida Lake. Here are two rows of weirs, each consisting of three traps or pots (Figs. 224, 225). The Eels are trapped when at maturity they descend the river to spawn in the sea. They are then taken from the traps and stored in cages (Fig. 227) until a sufficient number has been accumulated to sell. These were formerly sold at Brewerton to Davison and Coville, who smoked and marketed them. About 100 tons of Eels were handled a year. Of these about three tons were smoked. About 300 pounds were smoked each week, from the

middle of May to the middle of September, or in about 20 weeks. The Eels are skinned, split open, cleaned, washed and salted, then rinsed and hung up to drain for an hour or so in the smokehouse (Fig. 228). A wire screen is suspended below the Eels to catch them in case any should fall, as they are liable to do if cooked too rapidly, preliminary to smoking. A quick fire is started, with corn cobs and sawdust, and then it is converted into a slow smudge. By adding sulphur to the fire a rich brown color is given which greatly aids the sale. The time required for smoking varies from four to fifteen hours, but the cause of this great difference in time is not known. The smoked Eels sold, in 1916, at 20 cents per pound wholesale; the undressed Eels retail at 6.5 cents per pound, and the unsmoked at 10 cents per pound.

In 1916-17 the Eels were smoked at Caughdenoy by the licencees of the weirs, and we are indebted to Mr. C. J. Campbell for some of the details of this feature. The Eels are taken from the weirs in the early morning and stored in cages until a few hundred have been accumulated. On the evening previous to dressing the fish the storage cages are hauled up on the shore to allow the Eels to die by suffocation, and they are then ready for dressing. They are hung up, skinned, cleaned, washed and scrubbed with a brush to remove the blood, and salted overnight. The next day the salt is washed off, and then they are hung up in the smokehouse and smoked for four or five hours. In the summer of 1917 the smoked Eels were sold, wholesale, at 23 cents a pound and a very small number of fresh dressed Eels were sold at 14 cents a pound. Smoked Eels retailed at Syracuse, N. Y., during the summer of 1917, at 40 cents a pound. The smoked Eels will keep about 10 days. The Caughdenoy smokehouse has a capacity of 370 Eels. In 1928 live Eels retailed at 20 cents a pound and smoked Eels at 35 cents, at the Brewerton market. Mr. Campbell prepares a small amount of Eel oil, which is sold largely as a grease for harnesses, but also for medicinal purposes. This is a clear yellowish oil which retailed at \$1.50 per quart in 1917. Only a few Eel skins are preserved. The tubular fresh skins are stretched over thin, narrow boards about a yard long (Fig. 226), to dry. When dry they are split along the belly and pressed flat. They are sold for 10 cents each. About 15 years ago Eel skins were saved in rather large numbers and sold for \$30 a thousand for lining whips. Probably 6,000 skins a year were thus shipped.

The average weight of individual Eels is about four pounds. Mr. Coville had one weighing $7\frac{1}{4}$ pounds, which was probably about $3\frac{1}{2}$ feet long (Adams and Hankinson, '16, pp. 159-160).

In Italy, according to Stevenson ('99, pp. 270-271), Eels are pickled. One method is as follows: "The dressed Eels are sprinkled with salt, which is soon rubbed or wiped off; then the Eels, cut in pieces of suitable length, are spread with butter and broiled brown upon a gridiron. The pieces are next placed in suitable receptacles, such as jars, kegs, etc., and among them is spread a mixture of bay leaves, whole cloves, pepper, English spices, and a little mace. A weight is placed on the mass to keep it compressed and the receptacle is covered. After 24 hours the weight is removed, vinegar added to cover the pieces, and the receptacle tightly sealed." The same author discusses (l.c., pp. 504-505) methods of smoking eels.

In New York the weirs and lines are licensed by the State. A record of the catch has kindly been furnished us by Mr. M. C. Worts, Superintendent of Inland Fisheries of the Conservation Commission, Albany, N. Y., as follows:

TABLE NO. 9. SHOWING CATCH OF EELS BY WEIRS AND LINES IN INLAND WATERS OF NEW YORK STATE, FOR THE YEARS 1913-'14-'15

<i>Localities</i>	<i>Lbs., 1913</i>	<i>Lbs., 1914</i>	<i>Lbs., 1915</i>
Chaumont and other bays, Lake Ontario, New York State.....	62,508	80,778	65,498
Sodus and other bays on south shore, Lake Ontario....	2,295	2,416	2,218
Lake Ontario.....	18,010	1,905	830
Niagara River.....	915	1,080	1,555
Seneca and Cayuga Lakes and Seneca River.....	1,420	527	165
Oneida and Oswego Rivers.....	41,635	33,839	34,511
Hudson River.....	2,573	4,129	6,605
Other waters of New York.....	2,235	404	986
Sturgeon lines, Lakes Erie, Ontario and the St. Lawrence River.....	4,405	2,149	530
Total pounds of Eels for New York State from above sources.....	135,996	127,227	112,898
Number of set lines (2,750 for 1915) estimated to average 10 lbs. per line.....			27,500
Total production for State for 1915 (about 70 tons).....			140,398

We do not feel, however, that the statistics at all adequately represent the catch of Eels in the State. Mr. Worts wrote that the records were not complete. The practical difficulties in securing accurate statistics on Eels have been pointed out by Meehan ('05). For the status of the Eel fishery on Oneida Lake and River in 1904, reference should be made to Cobb ('04, pp. 233-236), and the Federal statistics on Eel production for the United States for 1908 are given in a special report for 1911 (Durand, '11, pp. 27, 30, 36).

At present almost no effort whatever is made to use the skins of Eels. Stevenson ('03, p. 351) says: "Eel skins have been largely used in Europe for binding books, and to a considerable extent in making whips, and have also been tanned and dyed and made into suspenders. In Tartary they are dried and oiled and used as a substitute for glass in windows."

At the present time Eels are of considerable commercial importance in New York State. Macdonald ('27, p. 98) says that in 1925 there were 19 Eel weirs and 479 Eel pots licensed for use in the waters of the State. The operators of these devices, exclusive of those operating in the Hudson River, reported taking 52,951 pounds of Eels valued at \$6,474.33. They received an average of 12c a pound for their product. The Conservation Commission receives a license fee of \$20 for the operation of an Eel weir and 50¢ for an Eel pot. Macdonald (l.c.) gives the following figures for the Eel Fishery in New York State for 1923:

Lake Ontario	9,471 lbs., value	\$692.54
Chaumont and Black River Bays of Lake Ontario....	47,781 lbs., value	4,136.79
Port Bay, off L. Ontario.....	312 lbs., value	34.52
Niagara River.....	854 lbs., value	61.30
Hudson River.....	12,745 lbs., value	2,439.45
Miscellaneous waters.....	183 lbs., value	39.20

The injury done by Eels may be looked upon as one factor in the cost of production. Smith ('13, p. 1446) says that "It is not destructive to fishes in the way that many of our best game and food fishes are, but it preys extensively on small fry. The principal damage done by the Eel, however, is to the spawn of food fishes. This is consumed in great quantities, especially at night. The shad and herring are among the principal sufferers." They are also very destructive to fish caught in gill nets. At New Bedford, Massachusetts, and in New York City they have been taken in the city water pipes (Nye, '83, p. 273).

The dam at Caughdenoy, a part of the Barge Canal system, has no fishway, but the canal probably furnishes a passageway for some of the young coming up from the sea, via Lake Ontario. A detailed study of the Eel is desirable in order to gain a clearer understanding as to its status in the lake.

Spearing and Angling. Late in May Eels are speared near the shore, on gravel bottoms. Night lines are also very successful in catching Eels, the usual bait being worms, crawfish, and cut bait from Perch and dead minnows. The line is set at the bottom. Several fishermen have told of seeing Eels resting on eel grass (*Vallisneria*). They are speared among the water plants and are often found in clusters, as many as 6 or 8 in a tangle.

W. H. Weston and J. D. Black inform us that Eels are often speared on Eel shoals, at the mouth of Chittenango Creek, where the water is 5 to 10 feet deep. This is done early in July, in the "eel-fly season," when the Mayflies (Ephemera) float in windrows (see Fig. 229). As the Eels congregate among these Mayflies they are speared during the day or at night with what is called a "top-water spear." This is a long-handled implement about 16 feet long with a nail-like spear at the end to which are lashed two flexible tines (of ash or tamarack-root) which compress the Eel and cause it to coil around the fork and handle. The Eels found floating are speared with this implement, and the coiled Eel is pulled off in the boat by means of the feet of the operator.

Kendall and Goldsborough ('08, p. 37) state that in Connecticut Lakes, N. H., "Some of them are caught on night lines, others on live bait in still fishing, at which time some were hooked when not more than 5 or 10 feet below the surface, although the water was about 60 feet deep. The bottom here was soft mud. The angler sometimes hooks an Eel which by its vigorous pulling, tugging and shaking causes him to think that he has a trout of generous proportions. But dismay, disgust, and infinite trouble and slime accompany the advent of the capture into the boat."

References. Adams and Hankinson, '16; Bartsch, '03; Bean, '07, '13; Cheney, '99; Cobb, '04; Durand, '11; Eigenmann, '01; Eigenmann and Kennedy, '01; Evermann and Clark, '15, '20; Fisher, '93; Fowler, '06, '08, '13; Goode, '84; Grassi, '99; Hofer, '06; Howard, '14; Jordan, '82, '05; Kendall and Goldsborough, '08; LaRue, '14; Leidy, '04; Linton, '00, '01, '05; MacCallum, '95; Macdonald, '27; Meehan, '05; Meek, '16; Nye, '83; Oberholser, '06; Petersen, '01, '08; Rhoads, '03; Schmidt, '25; Smith, '13; Stevenson, '99, '03; Stiles and Hassall, '08; Tracy, '10; Taverner, '15; Warren, '97; Wilson, '02.

Fundulus diaphanus menona Jordan and Copeland. BARRED KILLIFISH, HARD HEADS. Barred Killifish were found numerous in many parts of Oneida Lake where the water was very shallow close to the shore. They could be seen

poised near the surface or darting before us as we waded. Their quick movements and the shallow water in which they dwelt made it hard to catch them in nets. Fishermen who get them when catching minnows may easily distinguish them from other small fishes by their broad grayish backs and heads and the dozen or more dark bars on the sides, and by the conspicuously superior mouth with prominent protractile premaxillaries. They are called "Hard Heads" by Oneida Lake fishermen.

Breeding Habits and Life History. Little is recorded on the breeding habits and the life history of this species. Forbes and Richardson ('09, p. 212) found females of the subspecies *menona* moderately distended with eggs, in August, in Illinois, and Eigenmann ('95, p. 252) found eggs, in June, in bottom grass of a lake in Northern Indiana. Wright and Allen ('13, p. 5) give the breeding time for *Fundulus diaphanus* as June 24 to August 3, and the breeding place as grassy bottoms. The species is a small one and is usually considered as one of the minnows. It reaches a length of four or five inches. The largest taken in Oneida Lake were $4\frac{1}{2}$ inches long (No. 585). Evermann and Clark ('20, p. 372) described certain activities of pairs of this species, which appeared to be associated with spawning habits.

Habitat. The species has a strong preference for very shallow water during the warm season of the year. A scant growth of partly submerged vegetation like *Dianthera*, rushes or sedges seems to be congenial to it, but it appears to avoid areas with abundant plant life. It was more often found in Oneida Lake over sandy bottoms than over rocky ones, perhaps because the former was most prevalent in the very shallow water where killifish like to dwell. The broad sandy shallows at the east end of Oneida Lake form an ideal habitat for these killifish and on September 9, 1927, we found them very abundant there, with many of them landlocked on beach pools (Coll. No. 4270 and Figs. 217, 218).

It apparently does not frequent the mouths of the streams tributary to Oneida Lake in any numbers, at least not during the summer. Only three very small specimens were taken by us from the tributaries, and these were from Scriba Creek (No. 76), Fish Creek (No. 515), and a creek entering Big Bay (No. 116).

Barred Killifish appear to have different habitat preferences in different parts of the country. Reed and Wright ('09, p. 399) found them about Ithaca in the lower courses of streams, flood lanes and marshes, as well as in Cayuga Lake. Cox ('97, p. 50) found the subspecies *menona* in muddy brooks and ponds where there was aquatic vegetation. Hay ('94, p. 236) considers their habitat to be the colder, clearer waters of streams and springs. Meek and Hildebrand ('10, p. 299) say that the fish inhabits small streams and lakes with clear water. According to Radcliffe ('15, p. 2), *Fundulus diaphanus* occurs in lakes and rivers but prefers the small streams, thriving best in small brooks and overflowed ponds adjacent to water courses. Bensley ('15, p. 36) gives somewhat weedy and rather open water as its habitat.

Food. Forbes ('83, p. 71) examined eight Illinois specimens of *menona* and found $\frac{4}{5}$ of the food to be animal matter and the remainder vegetation. The latter was made up of filamentous algae and seeds of various plants that had fallen into the water, and these were present in too large quantities to have been taken

accidentally. The animal food was composed of insects, terrestrial and aquatic, including *Chironomus* larvae, Hydrophilidae and Ephemeridae, and also spiders, amphipods, and entomostracans.

Hankinson ('08, p. 209) found *Chironomus* larvae, ephemerid nymphs, entomostracans and filamentous green algae in Walnut Lake specimens of the Barred Killifish. Pearse ('15, p. 16) examined the food of 49 specimens from Lake Mendota, Wisconsin, and found insects, adults and larvae, mites, amphipods, entomostracans, snails, nematodes and plants.

Baker ('16, p. 179) gives a summary of important data on the food of *Fundulus diaphanus*, and J. P. Moore ('22, p. 29) gives a table showing results of a study of the food of 48 specimens from New Jersey, of which (p. 30) he says: "Chironomid larvae constituted the largest single item, or about 33%; other insect remains, 11%; crustaceans (with the exception of a few isopods), 19%; miscellaneous animal remains, 13%; and plant remains, mostly filamentous algae, organic ooze, and debris, 20%." Greeley ('27, p. 63) reports the food of one of these Killifish about 1½ inches long as 70% Crustacea (mainly *Hyaella knickerbockeri*) and 30% *Chironomidae*. Pearse ('18, p. 262), from the examination of the food of 149 specimens found the fish eating a large variety of objects, which he lists as fish embryos, .8%; insect eggs, .8%; insect larvae, 23.4%; pupae, 1.7%; adult insects, 2.7%; mites, 3%; amphipods, 14.1%; entomostracans, 35.9%; Sphaeriidae, .4%; snails, 3.5%; oligochaete worms, 2%; plant remains, 5.5%; algae, .9%; silt and debris and some nematodes, 4.2%. Evermann and Clark ('20, p. 296) found the stomachs of four of these Killifish to contain snails, water mites, *Bosmina* and *Cypris*.

Distribution Records. The following collections contained examples of this species: No. 76, Scriba Creek; No. 77, Bullhead Bay; No. 83, Johnson Bay; No. 86, Poddygut Bay; No. 90, Chittenango Creek; No. 92, Maple Bay; No. 99, Walnut Point; No. 100, Ladd Bay; No. 102, Ladd Point; No. 105, Muskrat Bay; No. 116, Creek entering Big Bay; No. 119, Shaw Bay; Nos. 120, 121, Big Bay; No. 122, Shaw Bay; No. 137, Long Island; No. 305, Brewerton; No. 401 Billington Bay; No. 418, Lakeport Bay; No. 422, Mathews Point; No. 441, Taft Bay; No. 456, West Potter Bay; No. 475, Short Point Bay; No. 491, Three Mile Bay; No. 498, Messenger Bay; Nos. 500 and 502, Lewis Point; No. 507, Upper South Bay; No. 515, Fish Creek; No. 522, Frenchman's Island; No. 523, Short-Point Bay; No. 526, Maple Bay; No. 539, Dunham Island; No. 543, Frenchman's Island; No. 569, Willow Point; No. 585, Lower South Bay; No. 501, Sylvan Beach; No. 599, Brewerton; No. 603, Fairchild Bay; Nos. 610, 611, Lower South Bay; No. 617, Brewerton; No. 4270, Sylvan Beach.

Enemies and Disease. Diseased fish of this species were found in four of our collections: Nos. 558, 599, 622, 626. Bean ('03, p. 313) gives black bass and trout as its fresh water enemies. According to Fowler ('13), it is eaten by the American Merganser (*Mergus americanus*), Red-breasted Merganser (*M. serrator*), Horned Grebe (*Colymbus auritus*), American Bittern (*Botaurus lentiginosus*), Least Bittern (*Ixobrychus exilis*), Night Heron (*Nycticorax nycticorax naevius*), and Solitary Sandpiper (*Helodromas solitarius solitarius*). In addition to these he lists ('06, p. 196): Great Blue Heron (*Ardea herodias herodias*), and Green

Heron (*Butorides virescens*). Evermann and Clark ('20, p. 623) found this fish in the stomach of a Water Dog, *Necturus maculosus*, as well as in the stomachs of the Horned Grebe (*Colymbus auritus*) (l.c., p. 487) and the Pied-billed Grebe (*Podilymbus podiceps*) (p. 490). Several trematode parasites have been found in the species (Evermann and Clark, '20, p. 296).

Economic Relations. Barred Killifish are undoubtedly useful to some extent along with other small fish in furnishing food for black bass and other large important species in Oneida Lake (Bean, '03, p. 313; Smith, '07, p. 149). They are furthermore destroyers of mosquitoes (Seal, '10, p. 835; Chidester, '16, p. 4), and their habits of going into very shallow water makes them especially valuable in this respect. Chidester (l.c.) doubts, however, if they should be used in stocking waters for the purpose of removing mosquito larvae, on account of their aggressiveness toward more peaceable kinds of fish. This is manifest in an aquarium (Bean, '03, p. 313) where they injure the fins of other fish. Radcliffe ('15, p. 3) considers the species "effective against mosquitoes, but its alleged habit of feeding on the eggs and young of other species may militate against its introduction into waters stocked with more valuable species."

Angling Notes. Evermann ('07, pp. 347-348) considers that Barred Killifish are especially valuable as bait for black bass when these fish are feeding near the surface. They live well in confinement.

References. Baker, '16; Bean, '03, '07a; Bensley, '15; Chidester, '16; Cox, '97; DeKay, '42; Eigenmann, '95; Evermann, '01; Evermann and Clark, '20; Forbes, '78, '83; Forbes and Richardson, '09; Fowler, '06, '14; Greeley, '27; Hankinson, '08; Hay, '94; Meek and Hildebrand, '10; Nash, '08; Pearse, '15, '18; Radcliffe, '15; Reed and Wright, '09; Seal, '10; Smith, '07; Wright and Allen, '13.

***Percopsis omisco-maycus* (Walbaum).** TROUT PERCH. This species (Fig. 213) was found abundantly represented in a number of the shallow water areas during the early summer of 1916. Systematically this is one of our most interesting forms for it is intermediate in structure between soft-rayed and spiny-rayed fishes. Its adipose fin, abdominal ventral fins and naked head are features of the *Salmonidae*; and its ctenoid scales, fin spines, and the form of its mouth, make it appear related to the *Percidae* (Jordan and Evermann, '96, p. 782).

Breeding Habits and Life History. Trout Perch are always small, seldom over six inches in length. Nash ('08, p. 77) gives their maximum size as about eight inches. The species spawns in spring. Ripe females were taken by us from Douglas Creek (Fig. 38) at Lakeport, on June 22, 1916. They were in a large school in shallow, turbid water over a rocky bottom (No. 413). Bean ('07, pp. 187, 215) notes that they spawn in Scriba Creek at Constantia. The species is known to run up streams to spawn (Nash, '08, p. 77). Wright and Allen ('13, p. 5) state that it spawns in swift, gravelly streams. They give the breeding time for the Ithaca region as May-June. Forbes and Richardson ('09, p. 226) say that it spawns in spring and that females greatly distended with eggs were caught in Illinois on March 10.

Habitat. The species appears to live in the deeper water of Oneida Lake in late summer, for we took no specimens in shallow water of the lake or streams in our September collections. Colbert ('16, pp. 28, 30) found them in ten or more



Fig. 228. Smokehouse used for smoking Eels.



Fig. 229. Bodies of May-flies on water surface of Oneida Lake. June 30, 1916.



Fig. 230. Large-mouth Black Bass (*Micropterus salmoides*).

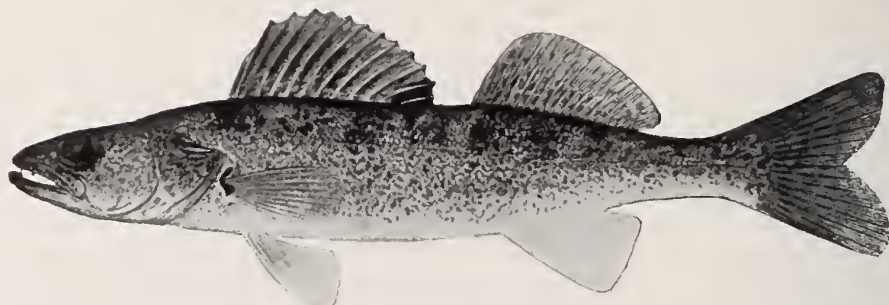


Fig. 231. Pike Perch (*Stizostedion vitreum*).

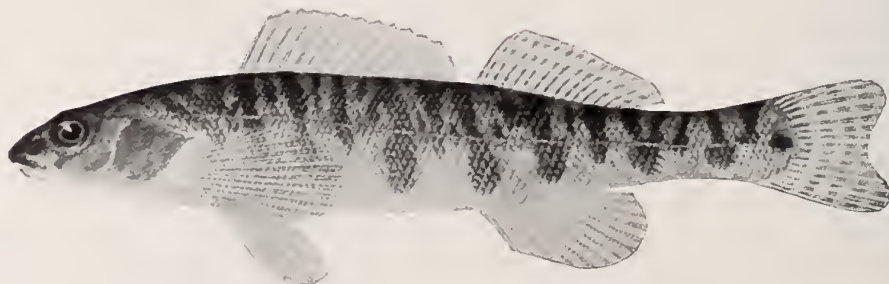


Fig. 232. Manitou Darter (*Percina caprodes zebra*).

feet of water in Douglas Lake in summer. It inhabits deep, cold water, according to Bensley ('15, p. 37). In the early part of the summer of 1916, from the middle of June, when our field work began, to July 6, we found them common in the shallow water of Oneida Lake. We found them in a stream (Douglass Creek) in June, where they were in all probability spawning. About Ithaca, N. Y., Hankinson used to take them in the marsh-bordered lower part of Fall Creek, close to Cayuga Lake. They were especially apt to be found in a slough connected with this stream. Reed and Wright ('09, p. 399) record them from these situations about Ithaca.

Food. Two specimens (No. 456) from West Potter Bay, taken June 27, 1916, had many insect fragments in their stomachs. Reighard ('15, p. 231) notes the finding of the chitinous parts of an insect larva in one fish. Few food studies apparently have been made of this species.

Clemens ('24, p. 128) shows by a table the food of nine Trout Perch from Lake Nipigon, Ontario. He found chironomids, amphipods, ephemerids, entomostacans, oligochaete worms, and some other invertebrates making up the food. Greeley ('27, p. 63) found a fish $3\frac{1}{4}$ inches long from the Genesee River to have eaten chironomid larvae, *Cyclops*, an adult fly, and a black fly larva (*Simulium*).

Distribution Records. All of the fish caught during June and early July are in the following collections: No. 400, Froher Bay; No. 413, Douglas Creek; No. 447, Potter Bay; No. 448, Bernhard Bay; No. 453, the bay just west of Potter Bay; Nos. 456, 464, Potter Bay; Nos. 500, 502, Lewis Point; Nos. 517, 518, Sylvan Beach. Two dead fish (Nos. 122, 124) were found floating in the lake in September, 1916, and one (No. 550) on July 14, 1916.

Enemies and Disease. Two of the dead specimens we found were diseased (Nos. 407, 550); one had water mold on its tail. Trout Perch are known to be afflicted with an eye disease that destroys one or both eyes. Examples so diseased have been found in Scriba Creek in spring (Bean, '07, p. 215). The disease is apparently bacterial and seems to have been of recent origin in Scriba Creek. It lasts till freezing weather and affects many species of small fish, but never large ones. There is considerable mortality among Trout Perch in some regions. Leathers ('11, p. 251) found many dead in Saginaw Bay. Colbert ('16, p. 34) found over 700 beached at Douglas Lake. The species is eaten by Pike Perch (Bean, '07, p. 215).

Economic Relations. Since the species is evidently abundant in Oneida Lake and is preyed upon by that important game fish the Pike Perch, it is undoubtedly for this reason of economic value in the lake and is worthy of considerable study to find to what extent it is a food for Pike Perch and other fishes. In lakes where Pike Perch are to be encouraged, it may be found profitable to plant Trout Perch. On account of the accessibility of their spawning grounds, the ease with which they are caught on them, and the ease with which captured gravid females give up their spawn, it appears that Trout Perch might be easily propagated by hatchery methods for the purpose of stocking Pike Perch waters. Little appears to be known of the value of the species as bait, but Bean ('92, p. 84) says that it is doubtless excellent.

References. Bean, '07, '92, '97; Bensley, '15; Clemens, '23, '24; Colbert '16; Forbes and Richardson, '09; Greeley, '27; Jordan and Evermann, '96; Leathers, '11; Nash, '08; Reed and Wright, '09; Reighard, '15; Wright and Allen, '13.

Lepibema chrysops (Rafinesque). STRIPED BASS, WHITE BASS. The White Bass resembles the Striped Bass, *Roccus lineatus*, which lives in the Atlantic and runs up streams to spawn, sometimes occurring in Lake Ontario. The White Bass is thought to have originated from land-locked Striped Bass. The species does not appear to be common in Oneida Lake at the present time, for we could get no information of any numbers being taken there very recently. Bean ('13, p. 271) says the State Conservation Commission took over 700 in Oneida Lake while getting Black Bass for the breeding ponds at Constantia. We obtained but two small fish (No. 314), but got 8 from the market at Brewerton, with assurances from Mr. H. N. Coville that they came from Oneida Lake.

The species is easily distinguished. In form it is much like a black bass, but the sides are silvery with a number of dusky, longitudinal lines upon them.

Breeding Habits and Life History. Bean ('03, p. 523) says that in April and May, White Bass leave the deeper waters and go in near shore or to mouths of rivers where they spawn, and that the spawning period is May and June. Later ('13, p. 271) he records its spawning place as near shores or in river mouths and the time as April and May. Wright and Allen ('13, p. 6) corroborate him in this last statement, except that they give the breeding time as May and June. Henshall ('03, p. 87) states that it performs a semi-migration in spring, entering the tributaries of lakes in large schools, and that it spawns usually in May.

This fish grows to a length of 15 inches (Jordan and Evermann, '96, p. 1132) and a weight of 3 pounds (Bean, '03, p. 523). One of the specimens in our collection from Oneida Lake (No. 150) must have been near the maximum size for the species, for it was 14 inches long.

Habitat. White Bass, both adults and young must be confined very closely to the deep water of Oneida Lake, since none was taken in our many collections made in the summer in shallow water; however, two small ones were taken here on October 18, 1915 (No. 314). It is possible that it is a habit of the young to come to the shoals during the cool seasons. Adult White Bass are very evidently deep water fish. Jordan and Evermann ('96, p. 1132) say that it frequents deep, still waters, seldom ascending small streams. Bean ('03, p. 523) considers it a fish of the deeper parts of rivers, thriving best in lakes and ponds. Henshall ('03, p. 87) states that the White Bass is found in water of moderate depth, preferring those that are clear and cool, that it does not resort to weedy situations, and that it is essentially a lake fish, except at the breeding time. The ecological tables given by Forbes and Richardson ('09, p. 319) show its strong preference in Illinois for lakes and ponds rather than rivers and that a very small number are found in creeks. Nash ('08, p. 99) writes of its habitat and certain of its habits as follows: "The White Bass is found in the Great Lakes of Ontario; it rarely ascends streams, but occurs sometimes at the mouths of the larger rivers. It is gregarious, usually swimming in schools containing a large number of individuals."

Food. Bean ('13, p. 271) says that the White Bass feed naturally on minnows, crawfish, and other fresh-water crustaceans, small mollusks, and the young of fishes; it moves in schools while feeding. It is said to devour young whitefish

on their spawning grounds (Bean, '03, p. 523). Forbes' investigations of this species (Forbes, '78, p. 75; '80, p. 40; Forbes and Richardson, '09, p. 320; Baker, '16, p. 197) revealed May-fly nymphs, *Chironomus* larvae, other dipterous larvae, isopod crustaceans (*Isellus*), and small fish, including a sunfish, to be the food found in 11 Illinois examples. Marshall and Gilbert ('05, p. 522) found that in one of four specimens examined the food remains consisted of insect larvae.

Distribution Records. Bean ('13, p. 271) records the taking of 700 of these fish from Oneida Lake in 1912, and one was taken by Annin (Bean, '97, p. 241) in 1896. Two were caught by us (No. 314) at Brewerton, October 18, 1915. Eight were obtained from H. N. Coville, which were brought to his market at Brewerton (Nos. 150, 627). No. 4270 was taken by Hankinson and W. A. Dence, in pools on sand flats of Sylvan Beach, September 9, 1927.

Enemies and Disease. Ward ('12, p. 227) found 12 of 13 White Bass examined to be infested with parasites. Of these 295 were trematodes, an average of 25 to a fish. Two cestodes were found in each of the fish, and a nematode in one. Van Cleave ('22, p. 3) describes a new genus and species of trematodes from the White Bass taken in the Mississippi River system and at Sandusky, Ohio. He names the form *Allacanthochasmus varius*. It had not been found in any other host. Wilson ('16, p. 340) lists four species of mussel parasites on White Bass, *Anodonta corpulenta* Cooper on the fins, and *Lampsilus ligamentina* Lamarck, *Quadrula heros* Say and *Q. plicata* Say on the gills. He also obtained two species of copepods on the gills, *Ergasilus caeruleus* Wilson and *E. centrarchidarum* Wright; and on the fins or outer surface of the body he found *Argulus appendiculatus* Wilson. Surber ('13, pp. 114-115) found one White Bass out of 92 examined infested with mussel parasites, *Lampsilus ligamentina* Lamarck. In the four White Bass examined by Marshall and Gilbert ('05, p. 522), nematodes were found in the stomachs of two fish, and in the intestines of one. Acanthocephala were taken from the stomach of a single specimen. Ward and Magath ('16, p. 59) record a nematode parasite (*Camallanus oxycephalus* sp. nov.) from the intestine of a White Bass from Fairport, Iowa. None of our Oneida Lake White Bass show any superficial evidence of disease.

Economic Relations. The White Bass is one of the best of our food and game fishes. Its flesh is almost if not fully as good as the flesh of the black bass (Bean, '03, p. 523; '13, p. 271). Henshall ('03, p. 87) says of it: "It is a foodfish of much excellence, its flesh firm, white, flaky, and of good flavor." It is adapted for cultivation (Goode, '03, p. 32; Smith, '96, p. 458) and bears shipment well (Goode, '84, p. 429).

Since White Bass appear to be destructive to whitefish eggs (Bean, '03, p. 523), it is likely that they would devour Tullibee eggs in Oneida Lake in important numbers if they were much more abundant than they appear to be. The habits and food of this species should be studied in late fall when the Tullibeas are breeding. We obtained some evidence that the young, at least, come to shallow water at this time (No. 314). More information on the status of the White Bass in Oneida Lake is needed to determine if it is decreasing in numbers there, as our meagre data seem to show, and if so what the possible causes may be.

Angling Notes. The White Bass is a good game fish, and according to Forbes and Richardson ('09, p. 320), it may be caught with live minnows and even with grubs and angleworms. It will also rise to the fly. Bean ('13, p. 271) says that it may be caught with artificial fly or minnow, and that it will bite freely at night. He tells of as many as one hundred White Bass frequently being caught in a few hours.

The following is quoted from Henshall ('03, pp. 87-89): "It is one of the best fresh-water game-fishes, being a bold biter, and on light and suitable tackle affords much sport to the appreciative angler. For fly-fishing, the best season is during the spring, when it enters the tributary streams of lakes. At this time the fly-fisher will be successful at any hour of the day. He may fish from the bank or from an anchored boat, the latter plan being the best. As the fish are swimming in schools, either headed up or downstream, no particular place need be selected, though off the points at the edge of the channel, or in the narrowest portions of the streams, are perhaps the best. In the summer and fall the fish are in the lakes or deeper water, when the fishing will be more successful during the late afternoon hours until sundown. . . .

"A trout fly-rod of six or seven ounces, with the usual trout click reel and corresponding tackle, will subserve a good purpose. When the fish are running in the streams the most useful flies are gray drake, green drake, stone fly, brown hackle, gray hackle, Henshall, and Montreal of the usual trout patterns, on hooks Nos. 5 to 7.

"For bait-fishing, a light black-bass or trout rod, with multiplying reel, braided silk line of the smallest caliber, a leader of small gut three feet long, and hooks Nos. 3 or 4 tied on gut snells, will answer well. The best and in fact the only bait that can be successfully used is a small minnow, hooked through the lips. The fishing is done from an anchored boat on lakes or deep pools or streams, either by casting or still-fishing."

References. Baker, '16; Bean, '03, '07, '13; Forbes, '78, '80; Forbes and Richardson, '09; Goode, '84, '03; Henshall, '03; Jordan and Evermann, '96, '02; Marshall and Gilbert, '05; Nash, '08; Smith, '96; Surber, '13; Van Cleave, '22; Ward, '12; Wilson, '16; Ward and Magath, '16; Wright and Allen, '13.

Perca flavescens (Mitchill). COMMON PERCH. The Perch (Plate 1) is the most abundant and best known of all of the food and game fishes in Oneida Lake. Campers and cottagers interested in the small inland lakes of Northeastern United States and people who patronize fish-markets know the Perch and are familiar with its qualities as an object of sport and as a table fish. Goode ('03, p. 6) writes of the Perch: "A fish for the people it is, we will grant, and it is the anglers from among the people, who have neither time, money nor patience for long trips and complicated tackle, who will prove its steadfast friends." Jordan and Evermann ('03, p. 366) say that "the Yellow Perch is a fish that can be caught by women and children, who do not, as a rule, seek the more noble game fishes; and many an inland summer resort is made vastly more attractive because our wives and children who are spending the summer at the little inland lake are always able to bring in good strings of delicious Yellow Perch." Not only are many fish brought in during the summer fishing season, but large numbers are caught in the winter

through holes in the ice, and on mild winter days Perch fishing is attended with considerable sport. Its numbers do not seem to be reduced by extensive fishing in Oneida Lake or similar large bodies of water. The species holds its own by being very prolific and adaptable, through a lack of specialization as to food and habitat (Jordan, '25, p. 522; Pearse and Achtenberg, '20, p. 335).

The reason why people generally are so well acquainted with the Perch lies not only in its table and game qualities but in the ease with which it can be identified. Its distinctive features are prominent, such as its subcylindrical form, spiny fins, and peculiar ringed color pattern. There are seven broad dusky bars over its brassy sides and its belly is white, with reddish lower fins. When seen in the water of its habitat the markings are prominent, and make the Perch easily recognizable. The banded appearance also identifies the young when two inches or more in length.

Breeding Habits and Life History. Perch do not construct nests of any kind but lay their eggs embedded in long gelatinous strings in shallow water, apparently with little reference to the bottom. Reighard ('15, p. 244) found the eggs attached to submerged parts of water plants. Embury ('15, p. 226) says the strings are woven among plants, submerged branches and logs, and he describes ('22, p. 13) the principal breeding ground of the species in Cayuga Lake as the southwest corner, part of which is margined by cat-tails and water willows while another part has rocky or gravel shores. The egg masses have been found floating in this place, resting on gravel or muddy bottom, or, as is more commonly the case, entwined loosely about the submerged stems and roots of the willows and aquatic plants. Embury notes that the spawn is sometimes loosened from such situations and cast upon shore and destroyed. Goode ('03, p. 4) also notes the adherence of egg strings to stones, twigs, etc.

Spawning occurs in early spring in Oneida Lake. On April 20, 1920, Mr. C. E. Hunter found nets taken up by game protectors, "plastered with eggs of Perch." Bean ('02, p. 404) considers the spawning time of the Perch to extend from December to April. Surber ('20, p. 74) gives May as the spawning time in Minnesota and says that it takes place at night, the season lasting from two to four weeks. Reed and Wright give the first of April as the time for the Ithaca region. April and May is the time according to Forbes and Richardson ('09, p. 277), and at a temperature of 44°-49° F. Meehan gives ('13, p. 191) the time as February to May and the temperature of the water as 52°-54°. Titcomb ('22, p. 75) gives 44° F as the favorable temperature in Lake George. Pearse and Achtenberg ('20, p. 327) say Perch in Wisconsin Lakes spawn near shore at 45°-50° F.

The structure of the elongated egg mass has been described by Worth ('92, p. 332). It is a gelatinous substance, adhesive and transparent. The individual eggs measure about 1/3 inch, according to Jordan and Evermann ('03, p. 367), and there may be many thousands of them in one string; Worth noting from about 2,000 to 90,000 ('92, p. 333). The strings are zig-zag in form and variable in length. Worth (l.c., p. 332) found one spawned in an aquarium, which was 7 ft. 4 in. long, and 4 in. wide at one end, 2 at the other, and weighed 2½ pounds. A portion of his detailed description is here given: "The arrangement of the transverse folds corresponds in structure to the leather sides of a bellows or accordion.

. . . Close examination of the egg-lobe revealed the existence of an interior passage throughout its length. The inner cavity was almost entirely closed, being, however, slightly open to outside communication by means of occasional small apertures in the walls. These openings were so unimportant in size and number and of such irregular shape and occurrence that they were at first regarded as accidental. Commissioner McDonald, however, suggested that they formed a part of the system of natural circulation and therefore were probably essential to aeration, and further examination tended to support the view. The egg-lobe was characterized by great springiness, being in fact so highly vibratory that the least agitation of the surrounding water put the whole in motion. This movement evidently forces the water out and in, and hence the apertures seem to be a part of the design, which is a variety of pumping apparatus, for throwing out the stale water and taking in fresh supplies." The explanation is very plausible, and we see here probably another method of aeration of eggs which may be compared with the fanning action employed by centrarchids resting over eggs in bowl-shaped nests.

The hatching time for the Perch eggs is 27 days, according to Leach ('27, p. 21), at a temperature of 47° F.

In July, in Oneida Lake, large schools of the young of the year appear in shallows and at this time are about 1 to 2 inches long (Nos. 522, 552, 591). By August and September these young are about 2½ inches long, and the next summer, when perhaps 14-15 months old, they are near three inches in length. It appears from our collections that Perch grow to about 2½ inches the first year, but no critical study of the growth was made. Harkness ('22, p. 91) made a growth study of young Perch in Lake Erie, finding them at 6 months to be 2 inches, and at 18 months, 4 inches long. Embury ('15, p. 227) gives the following growth data for the Perch: 5 months, 2½ in.; 12 months, 3-4 in.; 2 years, 6-7 in. Here also the growth of the young Oneida Lake fish appear to be about the same as given by Embury. Bolen ('24, p. 308) obtained data on the growth of Perch in Winona Lake, Indiana, with the following results:

25 fish, 1 year old,	average length about 3 inches
31 fish, 2 years old,	average length about 4¼ inches
19 fish, 3 years old,	average length about 5⅜ inches

The mature fish vary considerably in size. Pearse and Achtenberg ('20, p. 339) note that in a smaller lake they become mature at a smaller size than in a larger one. In Wisconsin lakes (l.c.) Perch mature in about two years. At the spawning time males precede the females to shallow water (l.c., pp. 327, 339); and there are more males than females. Perch as caught by anglers are commonly under a foot in length and weigh less than a pound (Forbes and Richardson, '09, p. 277). In some lakes Perch of two pounds or more are common. The largest Perch ever taken, according to Nichols and Heilner ('20, p. 1), weighed 4 lbs. 3½ oz.

Habitat. Perch seem to inhabit all parts of Oneida Lake, the larger ones in deeper and the smaller ones in shallower water, with the very smallest in the marginal shallows. Persons who fish for Perch in inland lakes observe quite a close relation between size of fish and depth of water. Hankinson, who has fished for Perch in many lakes in Michigan, finds that in water about five to ten feet deep

the fish are usually small, mostly from about six to ten inches in length, and from the collections made at these depths in Oneida Lake this same relation between size of fish and depth of water was noticed there also. At these depths the water is usually clear enough to make fish visible, and rarely are any as much as a foot long seen; while in deeper water (thirty feet or so) large Perch may be taken, sometimes in quantities. There are, however, many exceptions to this general rule. In some lakes all the Perch are small, regardless of size and depth or other apparent conditions, while in others they run large. Pearse and Achtenberg ('20, p. 299) note such size differences in lakes near Madison, Wisconsin, and Dymond ('26, p. 83) describes similar instances in lakes of Ontario, while Bensley ('15, p. 46) finds the small size of Perch in Georgian Bay unexplainable when compared with larger fish of other waters. Lucas ('25, p. 94) gives instances from Massachusetts. A fully satisfactory explanation for this diversity of size in different bodies of water has not been made. Very probably the same explanation will not answer for all instances, and the condition is not peculiar to the Perch (Titcomb, '21, p. 12), but may be found with regard to trout and other species. Superabundance of Perch in a body of water seems to be correlated with the small size of the fish. Here the struggle for existence is so intense among the Perch that none grows large, and possibly there are other factors. Titcomb (l.c., p. 13), however, does not assign much importance to inbreeding for he sees no reason for this stunting of the fish and has observed that when these small Perch are transferred to larger bodies of water they become larger. When ponds are raised so as to cover two or three times the present areas, he would expect the Perch in two or three years to average much larger than before the increase of the water area. Small size then seems to be due to environmental rather than hereditary factors. Pearse and Achtenberg ('20, p. 339) conclude from studies of the fish in two lakes in Wisconsin where there is a difference in size of the Perch, that various adverse conditions prevent growth, but food does not appear to be as important as other factors, such as shallowness and exposure to the wind.

Pearse and Achtenberg have made the most thorough studies of the habitat of Perch that have as yet been made, and have reached some interesting and important conclusions. These undoubtedly apply to fish in regions having conditions similar to those in the lakes they investigated. It was found that Perch are able to live under a greater variety of conditions than can any of their associates (p. 335), and to invade all habitats, going below the thermocline and even into water without oxygen where they can remain for as long as two hours (l.c., pp. 323, 339).

Other observations and generalizations concerning the habitat of the Perch made by Pearse and Achtenberg ('20) are as follows:

When Perch invade water which does not contain sufficient oxygen for breathing they apparently draw on the supply in the swim bladder (p. 326).

In winter most of the Perch are in deep water. As soon as the lake is free from ice there is a migration inshore for spawning, but the Perch soon return to deep water and remain till lack of oxygen drives them into the shallower regions; but as soon as the oxygen is renewed in the overturn of the water in autumn, the Perch return to the depths of the lake (p. 329).

The nature of the food and the character of collections made in the lakes

both indicate that Perch remain on or near the bottom in as deep water as they can find during most of the year. The migrations into shallow water are for spawning purposes and to escape stagnant conditions during summer (l.c., p. 329).

All observations signify that Perch swim in schools throughout life (l.c., p. 332).

Perch do not change rapidly from one stratum of water to another (p. 316) for gill nets set at different depths brought up Perch as a rule that had been feeding at the particular levels where they were caught.

Perch come to the surface at night and early in the morning (p. 332).

The statements made by Pearse and Achtenberg apply particularly to the adult fish. It is well known, as before noted, that small Perch dwell in shallow water. Reighard ('15, p. 238) states that they go to deep water in Douglas Lake when about six inches long, and that small Perch less than $2\frac{1}{4}$ inches were common on shoals (p. 237). He sees (p. 241) an advantage in this schooling in that "There are more eyes on the watch for enemies" and "more chance that any individual will be warned by the flight movements of comrades, and thus be enabled to escape." There are two influences that keep the young fish on sand shoals, where they are commonly found; these are the abundance of plankton Crustacea for food, and the relative freedom from attacks of enemies. Turner ('20, p. 151) notes that young Perch, 1-2 inches long, dwell in two to five feet of water in Lake Erie. Hankinson ('08, p. 215) found schools of very young Perch in the shallows at Walnut Lake, and in many other inland lakes of Michigan. In Oneida Lake little Perch were extremely abundant in the shallows in the summer, and these were usually from about $1\frac{1}{2}$ to 3 inches. Our collection data make it appear that these young prefer shallows with patches of aquatic vegetation, or margins with partly submerged sedges, rushes and other shore plants. They like the vicinity of these plant growths but do not seem to enter them as do Mud Minnows, bullheads, pickerel, and sunfishes.

Perch are principally lake fish, but they also frequent many large streams, so are to quite an extent a river fish. Greeley ('27, p. 64), in his studies of the Genesee System in New York State, found Perch in lakes and in many ponds, but absent in most streams, except the largest. The species seems to prefer warm waters. Hankinson ('24) found no Perch in any of the collections made in the many small streams in western New York. No large streams were extensively examined, so the findings were similar to those of Greeley. Shelford ('13, p. 119) found Perch only in the larger lower courses of the streams near Chicago. Forbes and Richardson ('09, p. 277) report that 83 collections made by them in Illinois showed Perch to be found with about equal frequency in each of the three habitats: glacial lakes, bottom-land lakes and large rivers. At Oneida Lake, Perch were frequently found near the mouths of streams; and in one, Scriba Creek, small Perch are known to be very abundant at certain times, as in spring when the Pike Perch are spawning, and in the fall (Bean, '09, p. 213).

In the Great Lakes, Perch do not frequent the deepest water and are not taken in nets set in the deepest waters for ciscoes, lake chubs and Lake Trout. Milner ('74, p. 36) in his habitat classification includes the Perch among fishes which dwell in water twenty fathoms deep and shallower, and not with those most abundant in water of seventy fathoms and deeper.



Fig. 233. Fishing through the ice for Perch at Oneida Lake. February 6, 1921.



Fig. 234. Standard equipment and method of fishing through the ice for Perch at Oneida Lake. February 6, 1921.

Perch of the deeper waters of our inland lakes show a preference for aquatic vegetation. Hankinson ('08, p. 214) found them in the pondweed zone of Walnut Lake, and he has found most successful Perch fishing in other lakes where there is a scant growth of tall pondweeds in eight or ten feet of water. Reighard, however, ('15, p. 236) found that the larger Perch of Douglas Lake did not occur with aquatic vegetation; but those under six inches in length were taken where plants were abundant. Evermann and Clark ('20, p. 424) find Perch living among *Potamogeton americanus* in Lake Maxinkuckee, and the plant accordingly is called the "perch weed" in this locality.

The nocturnal distribution of Perch in a body of water shows some difference from the diurnal. With a search light at night large ones were seen in shallower water of Walnut Lake, while none were seen during the day (Hankinson, '08, p. 215). Pearse and Achtenberg, as before noted, found them coming to the surface at night.

In winter, Perch are very abundant and active in Oneida Lake, and large numbers are caught through the ice; fishing seems best in eight to twelve feet of water. Hankinson has caught many through ice in ponds and lakes in Michigan. Evermann and Clark ('20, p. 425) mention seeing large numbers through ice in Lake Maxinkuckee, showing the species to be active in winter in that lake also.

Food. The food of the Perch has been found, through studies of many fish from many waters, to be very diverse, a condition which we would expect from its wide geographic range. Generalizations concerning its food are thus difficult to make. It can be said that it consists principally of small living animals, largely insects, crustaceans and fishes. The young have a strong preference for minute crustaceans, but after the first summer their food is like that of the adult.

We opened many young Perch from Oneida Lake with a view of determining the food habits. Seven specimens, measuring about 2 to 3 inches, contained principally entomostracans, with Cladocera prominent. Chironomids and other aquatic insects were noted, including some corixids (No. 456). Two (Nos. 401, 416) had eaten fish eggs. Baker ('16, p. 192) also studied the food of seven young of these sizes and found small crustaceans, *Bosmina*, *Daphnia*, *Hyalella*, and some insects (odonates and chironomids).

Among adult Perch from Oneida Lake examined as to food habits, one, 6 inches long, had eaten a sunfish 2 inches long (No. 563). In February, 1921, Hankinson examined the catches made by ice fishermen at Oneida Lake and studied the stomach contents of many of the Perch they had caught in eight to twenty feet or more of water. These seemed to have eaten only burrowing May-fly nymphs of the *Hexagenia* type. These fish were caught on hooks baited with Perch eyes and small minnows.

Baker ('16, p. 192) found in seven Perch 4 to 8 in. long, from Oneida Lake, crawfish, Odonata nymphs, chironomid larvae, amphipods (*Hyalella*), a small mussel, and small fishes.

The large amount of data on the food of Perch in bodies of water other than Oneida Lake can not be incorporated in this paper, but an effort will be made to give the important findings published by different investigators, in the following table.

TABLE NO. 10. SHOWING THE FOOD OF PERCH EXCEEDING THREE INCHES IN LENGTH

Reference	Locality	Number of fish	Invertebrate and plant food	Vertebrate food
Pearse and Achtenberg, '20, p. 311	Wisconsin Lakes	1,147	<i>Chironomus</i> and other Diptera larvae, 27 or more species; ephemerid nymphs, several species; Odonata nymphs, many species; Trichoptera larvae, several species; larvae of <i>Sialis</i> and of Coleoptera; <i>Hemiptera</i> nymph. (<i>Plea</i>); many insect pupae; adult insects of six or more orders. Crustaceans: <i>Cambarus</i> , amphipods, isopods, entomostracans. Many mollusks. Worms, including leeches. <i>Arcella</i> . Algae, and parts of seed plants.	Fish as follows: <i>Notemigonus crysoleucas</i> , <i>Eucalia inconstans</i> , <i>Notropis heterolepis</i> , <i>Lepomis incisor</i> .
Pearse, '21, p. 266	Green Lake, Wis.	About 30	Insect larvae or nymphs: <i>Chironomus</i> , May-fly, <i>Sialis</i> , Trichoptera, dragonfly. Crustaceans: entomostracans, <i>Cambarus</i> , amphipods, mollusks (<i>Physa</i>), oligochaete worms, leeches, algae.	Fish, .5% of food.
Pearse, '21a, p. 31	Lake Pepin, Wisconsin	15	Immature insects, 56.6%; adult insects, 3%; eladocerans, 18.8%; mollusks, 5.8%.	Fish, 11.3%.
P. 45	Lake Geneva Wis.	19	Immature insects, 20% (about $\frac{1}{2}$ chironomids); amphipods, 20%; entomostracans, 40%.	Fish, 5.3%.
P. 40	Lake Michigan Wis.	27	Immature insects, 56.6%; crawfish, 13.3%; entomostracans, 12.3%; amphipods, 8.1%; isopods, 3.7%.	Fish, 19% (eiscoes and minnows).
Sibley, '22, p. 66	Lake George, N. Y.	52	Primary importance: chironomid larvae, ephemerid nymphs, amphipods, snails. Minor importance: Trichoptera larvae and entomostracans, winged ants, crawfish, elams, caddice flies, orlflies.	Fish taken in unimportant amounts.
DeRyke, '22	Winona Lake, Ind.	111	Entomostracans, amphipods, <i>Cambarus</i> . Aquatic insects (including larvae or nymphs): <i>Chironomus</i> , Trichoptera, <i>Dytiscus</i> and other beetles, Odonata, Ephemera. Snails.	Fish, including <i>Perca flavescens</i> , from one stomach; fish eggs from one stomach.
Pearse, '18, p. 269-270	Wisconsin Lakes, Mendota, Monona	61	Immature insects, including chironomids, odonates, ephemerids, Trichoptera, <i>Corixa</i> , <i>Gryllus</i> . Adult insects, aquatic and terrestrial; amphipods; snails and mussels; entomostracans; mites; oligochaete worms; algae and other plant material.	Fish, fish eggs, tadpoles.
Greeley, '27, p. 64	Genesee System, N. Y.	5	Larvae of <i>Chironomus</i> , Trichoptera, ephemerids; snails (<i>Physa</i>); amphipod (<i>Hyalella knickerbockeri</i>).	
Evermann and Clark, '20, p. 427	Lake Maxinkuckee, Ind.	....	Crawfishes (greater portion of food); nymphs of ephemerids and larvae; Odonata, Trichoptera; <i>Physa</i> and <i>Sphaerium</i> .	Small fishes: Stickleback (<i>Eucalia inconstans</i>); Johnny Darter (<i>Boleosoma nigrum</i>).

TABLE NO. 10. *Concluded*

Reference	Locality	Number of fish	Invertebrate and plant food	Vertebrate food
Reighard, '15, p. 236	Douglas Lake, Michigan	237	Crawfish, including a <i>Cambarus virilis</i> ; insects; copepod; earthworms; dragonfly nymph.	Undeterminable fish; also <i>Perca flavescens</i> .
Forbes and Richardson, '09, p. 277	Rivers in Illinois	18	Insect larvae, about 25%; Mollusks, 20%.	Fishes, about 6%.
Forbes, '80a, p. 39	.....	.....	Crustacea (<i>Cambarus</i> , <i>Palaemonetes</i>); amphipods, isopods, nearly 50%.	.....
Forbes, '80, p. 39	Lakes of Illinois, including Lake Michigan	12	.....	Fishes. Acanthopteri 56%; Cyprinidae, 28%; undetermined, 8%.
Marshall and Gilbert, '05, p. 520	Lakes of Wisconsin, near Madison	56	Insect larvae; amphipods; crawfish; snails (mostly <i>Physa ancillaria</i>); plankton; plant material.	Minnows in two Perch; fish eggs in three.

TABLE NO. 11. SHOWING THE FOOD OF YELLOW PERCH LESS THAN THREE INCHES IN LENGTH

Reference	Locality	Number of fish	Invertebrate and plant food	Vertebrate food
Pearse and Achtenberg, '20, p. 355	Lakes Mendota and Oconomowoc, Wis.	92	Insect larvae or nymphs, including <i>Chironomus</i> , ephemerids, Odonata, <i>Corixa</i> , <i>Sialis</i> , Trichoptera; Entomostraca; <i>Cambarus</i> , <i>Hyalella</i> ; <i>Physa</i> ; filamentous algae, and others.	
Pearse, '21a, p. 44	Lake Michigan	5	Chironomid larvae, 13.4%; chironomid pupae, 3.8%; damselfly nymphs, 6%; <i>Cambarus</i> , 16%; <i>Hyalella</i> , 32.8%; <i>Asellus</i> , 8%; Entomostraca, 12.6%; plant material.	Fish (<i>Micropterus dolomieu</i>) 3%.
Pearse, '21, p. 266	Green Lake, Wisconsin	2	Chironomid larvae, 25%; ephemerids, 2.5%; Trichoptera, 5%; <i>Hyalella</i> , 15%; Entomostraca, chiefly <i>Ceriodaphnia</i> , 52.5%.	
Pearse, '18, p. 269	Lakes Waukesha, Oconomowoc, Mendota, Wis.	44	Insect larvae or nymphs, including <i>Chironomus</i> , ephemerids, Odonata, <i>Corixa</i> ; entomostracans, amphipods; oligochaete worms; <i>Physa</i> ; adult insects; filamentous algae.	
Clemens, '23, p. 184	Lake Nipigon, Ontario	14	Insect larvae or nymphs: ephemerids, chironomids, <i>Corixa</i> . Insect pupae: chironomids and other Diptera. Adult chironomids.	Fish (Nine-spined Stickleback, <i>Pungitius pungitius</i>).
Clemens, '24, p. 133	Lake Nipigon, Ontario	79	Entomostracans, ephemerids, fish eggs, larvae of chironomids, <i>Corethra</i> pupae, Trichoptera larvae, <i>Corixa</i> ; water beetle larvae, hydraenids; Tipulidae, amphipods, <i>Diffugia</i> ; diatoms.	
Turner, '20, p. 148	Lake Erie	128	Entomostracans (copepods, Cladoeera, Ostracoda), amphipods, <i>Cambarus</i> , ephemerid nymphs, chironomid larvae and pupae, Trichoptera larvae, other insect larvae, adult insects; mites, snails, annelid worms, algae and other plant material.	Fish and fish eggs.
Moore, '22, p. 53	Lake George, N. Y.	92	Chironomid larvae, pupae and adults; amphipods, entomostracans, ephemerid nymphs, Odonata nymphs, Trichoptera larvae, <i>Cambarus</i> ; miscellaneous insects, snails, algae and other plant material.	
DeRyke, '22, p. 32	Winona Lake, Indiana	36	Entomostraca, amphipods, <i>Cambarus</i> , <i>Chironomus</i> , Trichoptera larvae, beetle larvae, Odonata and ephemerid nymphs, snails, hydraenids.	Fish and fish eggs.
Reighard, '15, p. 237	Douglas Lake, Mich.	203	Cladoeera (<i>Simocephalus</i> , <i>Daphnia</i>), copepods (about 812,000 total in enterons of all the Perch).	
Hankinson, '08, p. 249	Walnut Lake, Mich.	3	Copepods and other entomostracans.	
Forbes, '80, p. 38	Illinois	15	Entomostracans (Cladoeera, copepods, ostracods), isopods, amphipods, <i>Chironomus</i> , Ephemerida and Odonata nymphs, <i>Corixa</i> .	
Forbes, '80a, p. 84	Illinois	6	Daphnidae, 50%; copepods, 40%; <i>Chironomus</i> , 8%.	

Other notes on the food of Perch less detailed in character are here given. Kendall ('24, p. 308) notes the Perch feeds at times on Smelt (*Osmerus mordax*). Wilson ('20, p. 227) found 11 species of Odonata nymphs in 66 Perch. Surber ('20, p. 74) considers the Perch of Minnesota carnivorous, preferring minnows, and he says it has been accused of eating the eggs of other fishes, notably those of Pike Perch. Hankinson ('16, p. 151) found adult Perch in the shallow beaver ponds of the Whitefish Point region, Michigan, eating leeches almost entirely.

As to the methods of feeding, Pearse and Achtenberg made a number of important observations. They found ('20, p. 316) that Perch of the same size at the same time and place usually eat the same food, that they feed chiefly during the day, and that the food is more varied in shallow than in deep water. In general they take the food that is most abundant at the depth where they are found, and eat in proportion to its abundance and availability; but this is not always the case. They do not take any kind of food that may be abundant, but select certain things (l.c., p. 338). An adult Perch was found by Pearse and Achtenberg (l.c.) to eat about 7% of its weight in a day. Insect larvae are grubbed out of the soft lake bottom (l.c., p. 300). The fish is equipped for almost anything edible and is not a specialized feeder. The small backwardly directed teeth hold struggling prey, and the slender gill-rakers form a strainer for collecting microscopic food. They are adapted for snatching crawfish from among rocks and for securing aquatic insects from plants. The authors found that Perch feed on or near the bottom—in the summer on the bottom near the thermocline—and that there are seasonal variations in their food and feeding habits (l.c., p. 304). After the autumnal overturn they eat largely Cladocera and *Corethra*, and in the spring come in toward shore to feed among aquatic plants. Evermann and Clark ('20, p. 427) note a shoreward migration in Lake Maxinkuckee, in the fall, to feed on crawfish. Pearse and Achtenberg found that digestion in the Perch is three times more rapid in summer than in winter (p. 338).

Distribution Records. We made the following collections in shallows, mainly with minnow nets: No. 5, Lower South Bay; No. 7, South Bay; No. 75 R, Scriba Creek tributary; No. 76 G, Scriba Creek; No. 77 A, Bullhead Bay; No. 78 I, Bakers Point; No. 81 L, Ditch at Johnsons Bay; No. 86 M, Poddygut Bay; No. 87 K, Chittenango Creek tributary; No. 88 B, Chittenango Creek; No. 90 K, near Chittenango Creek; No. 94 D, bay near Brewerton; No. 99 H, Walnut Point; No. 113 C, Big Bay Creek; No. 116 N, Big Bay Creek; No. 118 D, Big Bay Creek; No. 119, bay near Shaw's Bay; No. 120 O, Big Bay shoal; No. 121 K, Ice House Bay; No. 122 F, Shaw's Bay; No. 138 C, Big Bay; Nos. 309 and 309 C, Lower South Bay; No. 314 L, near Brewerton; No. 345 G, Lower South Bay; No. 353 M, Brewerton; No. 400 C, Froher Bay; No. 401 A, Billington Bay; No. 403 C, Shackelton Point; No. 412 F, Lakeport Bay; No. 413 N, Douglas Creek; No. 416 K, Lakeport; No. 418 E, Lakeport Bay; No. 425 I, Dakin Bay Creek; No. 427 J, Dakin Bay; No. 441 J, Tafts Bay; No. 448 D, near Bernhard's Bay; No. 453 G, Bernhard's Bay; No. 456 F, West Potter Bay; No. 458 F, stream at East Potter Bay; No. 460 F, Black Creek, Cleveland; No. 470 H, bay east of Cleveland; No. 475 I, Long Point Peninsula; No. 482 E, Fairchild Bay; No. 483 K, Fairchild Bay; No. 490 E, Three Mile Bay; No. 498 H, Messenger

Bay; No. 500 K, bay west of Lewis Point; Nos. 501 J, and 502 K, bay west of Lewis Point; No. 507 G, upper South Bay; No. 511 E, Oneida Creek tributary; Nos. 517 P and 518 E, Sylvan Beach; No. 522 D, south of Frenchman's Island; No. 523 E, Short Point Bay; No. 526 H, Chittenango Creek; No. 539 H, north of Dunham's Island; No. 547 C, Chittenango Creek; Nos. 550 and 550 F, Godfrey Point; No. 552 I, bay at West Vienna; No. 563 D, Big Bay; No. 585 H, Lower South Bay; No. 594 H, near West Vienna; No. 599 E, Brewerton; No. 610 F, Lower South Bay; No. 621 F, Johnson's Bay Creek; No. 622 S, Brewerton; No. 626 P, near Brewerton; No. 4200 N, Maple Bay; Nos. 4270 and 4272, Sylvan Beach.

We collected the following in moderately deep (3-8 ft.) water, mainly with trammel nets: No. 469 C, East Potter Bay; No. 489 E, Three Mile Bay; No. 505 C, Upper South Bay; No. 512 C, Fish Creek; No. 515 D, Fish Creek; No. 4201 A, Kellar Bay; and No. 4205, Big Bay, were caught with hook and line through the ice.

We collected the following in deep water (8-20 ft.), mainly with trap nets: No. 103 A, Ladd's Point; Nos. 144, 145, 145C, and 146, Grass Island Bar; No. 555, Norcross Point; No. 567 B, Big Bay Creek.

The following were taken in deep or moderately deep water, with gill nets: Nos. 519 C, 549, 597 B, Norcross Point; No. 583 A, near Dunham's Island.

Pratt and Baker made the following collections in deep water mainly with trap nets: No. 1, Lower South Bay; Nos. 1205 E, 1207, 1216 B, 1264 D, Dry Land Point; No. 1233 E, North of Paddygut shoals; No. 1247 B, Muskrat Bay; No. 1269 A, off Frenchman's Island.

The following market collections are recorded: Nos. 327, 330, 342, 365 G.

The following were found dead: Nos. 85, 117, 440, 5605, 591, A, 591 J, 602 B, 611 Z.

Enemies and Disease. Perch are eaten by other fishes to a considerable extent. We found them in two stomachs of Wall-eyed Pike from Oneida Lake (No. 107), and Hankinson ('08, p. 247) made similar findings at Walnut Lake. Pike (*Esox lucius*) prey upon Perch (l.c., and Reighard, '15, p. 229; Greeley, '27, p. 62; Pearse and Achtenberg, '20, p. 332; Mead, '19, p. 1). A Perch 2½ inches long was taken by Hankinson from a Burbot that was caught through the ice of Oneida Lake, in 22 ft. of water (No. 4203). This species is well known to prey upon Perch in other regions (Pearse and Achtenberg, '20, p. 339; Forbes and Richardson, '09, p. 332; Hay, '94, p. 293). Titcomb ('22, p. 75) says that Perch are an important item in the menu of Smallmouth Black Bass. Lake Trout also eat Perch (Bensley, '15, p. 46), and Perch eat their own kind at times (DeRyke, '22, p. 32). Other fish enemies of Perch, according to Pearse and Achtenberg, are *Micropterus salmoides*, *Amia calva*, and *Lepisosteus ossesus*, while Forbes ('88, p. 510) mentions *Ameiurus nebulosus* also.

The eggs of Perch are eaten by aquatic birds and other animals, according to Goode ('03, p. 4) and Titcomb ('22, p. 75). Pearse and Achtenberg name the following species which eat Perch on the testimony of A. R. Cahn: Herring Gull, Common Tern, Black Tern, American Merganser, Red-breasted Merganser, Great Blue Heron, Green Heron, Black-crowned Night Heron, Loon and Horned Grebe. Fisher ('93, p. 32) adds the Osprey, and Nichols ('15, p. 37) records finding parts

of a four inch Perch about the nest of a Kingfisher. Lamprey scars were often seen on dead or dying Perch in Oneida Lake (No. 440).

Perch are subject to many diseases and have many parasites (Pearse and Achtenberg, '20, p. 339). They were frequently found dead in Oneida Lake, and were then usually covered with considerable water mold (No. 440). Marshall and Gilbert found only nine individuals seemingly free from parasites out of 72 examined ('05, p. 520). LaRue and others ('26, p. 285; Butler, '19, p. 116) found larval trematodes in the eyes of Perch taken from Douglas Lake, Michigan.

A list of important parasites of this species follows:

PROTOZOANS

Henneguya zwisconsinensis Mavor and Strasser. Pearse and Achtenberg ('20, p. 334).

TREMATODES

Bunodera luciopercae (O. F. Müller). Pearse and Achtenberg ('20, p. 334).

Bunodera nodulosa Zeder. Stafford ('04, p. 489).

Phyllodistomum superbum Stafford. Pearse ('24, p. 163); Stafford ('04, p. 492).

Clinostomum marginatum (Rudolphi). Pearse ('24, p. 171); Smallwood ('14, p. 11); Osborn ('11, p. 354); Pearse and Achtenberg ('20, p. 334); Pratt '23, p. 66.

Crepidostomum cornutum (Osborn). Pearse and Achtenberg ('20, p. 335).

Stephanophialia farionis O. F. Müller. Pearse ('24, p. 173); Faust ('18, p. 195).

Azygia longa (Leidy). Manter ('26, p. 72); Ward ('10, p. 1182).

Microphallus opacus Ward. Bangham ('26, p. 101).

Bucephalus pusillus Cooper. Ward and Whipple ('18, p. 379).

CESTODES

Proteocephalus pearsei La Rue. Pearse and Achtenberg ('20, p. 334); Bangham ('25, p. 256); La Rue ('19a, p. 117).

Proteocephalus ambloplitis (Leidy). Pearse ('24, p. 175); La Rue ('19a, p. 117).

Triacnophorus nodulosus Pallas. Pearse ('24, p. 176).

Diphyllbothrium latum L. Pratt ('16, p. 194).

Ligula intestinalis L. Pratt ('16, p. 193).

Bothrioccephalus cuspidatus (Cooper). La Rue ('19a, p. 117).

ACANTHOCEPHALA

Necochinorhynchus cylindratus (Van Cleave). Pearse ('24, p. 180); Pearse and Achtenberg ('20, p. 335).

Echinorhynchus thecatus Linton. Pearse and Achtenberg ('20, p. 335); Pearse ('24, p. 179); Van Cleave ('19, p. 9).

Echinorhynchus coregoni Linkins. Pearse ('24, p. 179).

Echinorhynchus salvelini Linkins. Pearse ('24, p. 179).

NEMATODES

Ichthyonema cylindraccum Ward and Magath. Pearse ('24, p. 178).

Dachnitoides cotylophora Ward and Magath. Ward and Whipple ('19, p. 530).

LEECHES

Piscicola punctata (Verrill). Pearse and Achtenberg ('20, p. 335).

Placobdella parasitica (Say). Pearse and Achtenberg ('20, p. 335); Ryerson ('15, p. 169).

COPEPODS

Ergasilus centrarchidarum Wright. Evermann and Clark ('20, p. 300).

Ergasilus caeruleus Wilson. Pearse ('24, p. 182).

Achtheres ambloplitis Killicott. Wilson ('19, p. 231).

MOLLUSKS

Lampsilus lutcola (Lamarck). Pearse ('24, p. 181).

Quadrula phacata (Say). Pearse ('24, p. 181).

Unio camplanatus. Lefevre and Curtis ('12, p. 168).

Economic Relations. It is generally conceded that the Perch is one of the best table fishes obtainable from our fresh waters. Jordan and Evermann ('03, p. 366) say that as a pan-fish they do not know a better one among American fresh water fishes. Sometimes the flesh has an ill flavor in fish from warm, weedy waters (Nash, '08, p. 92; Henshall, '03, p. 168), but in such cases the fish should be skinned before cooking (l.c.). Pearse ('25, p. 9) made an examination of the nutritive value of Perch flesh, using 64 fish from Lake Mendota, averaging about 6½ inches in length. The results were as follows: water, 76.21%; ash, 5.09%; nitrogen, 2.44%; fat, 2.87%. One objection to the Perch as a food fish is the difficulty with which the scales are removed, but here skinning can be employed.

The Perch is a fish of considerable commercial importance, and where netting is permitted, as in the Great Lakes, it is taken in large numbers for the markets. Hankinson has priced them in markets in Detroit and other Michigan cities in recent years and has found them selling at 25¢ to 35¢ a pound, and there seems to be a quick and ready sale for them. The largest numbers are sold in the spring, and at that time the majority of the fish which Hankinson saw in the markets were large females distended with eggs. The roe is often discarded by the marketman who dresses the fish for the customer, but it is saved through request and is delicious when fried with the Perch. It is evident that there is considerable waste here, through the marketing of so many adults about to spawn. There is manifestly a lack of concern for the future abundance of this useful species in the Great Lakes.

Leach ('27, p. 21) states that the Perch occupies an important place in commercial fisheries in the United States and is highly esteemed, that from the Great Lakes, the Potomac River, and the smaller lakes of the upper Mississippi Valley, large quantities are taken every year by means of fyke nets, gill nets, traps, seines and lines; and they find a ready market. He estimates the annual catch to be 5,700,000 pounds, valued at \$384,000, about 86% being credited to the Great Lakes. Koelz ('26, p. 584) notes a decrease of Perch in Lake Huron from a maximum recorded catch in 1899 of 2,740,669 pounds, to 633,188 pounds in 1922. He notes also a decrease for Lake Michigan (p. 566), based on testimony of fishermen. In Lake Erie, according to the tabulated figures (p. 592) showing pounds of Perch caught, there appears to be a fluctuation in numbers. The largest

catch was in 1899, of 3,315,000 pounds. The latest figures for 1922 show 2,969,000 pounds for Lake Erie (American waters). In Lake Ontario (p. 603) there is shown a decided falling off in the numbers of Perch taken. The maximum catch recorded here is 407,000 pounds in 1899, with only 30,000 pounds in 1922.

The present commercial value of the Perch in Oneida Lake is not known, but Cobb ('05, p. 239) gives for 1902, 13,400 pounds valued at \$670.

The value of Perch to New York State in 1925 is given by Macdonald ('27, pp. 92-95) as follows:

Lake Erie	47,428 lbs.; value	\$4,218.14.
Lake Ontario	8,674 lbs.; value	994.42.
Hudson River	26,834 lbs.; value	2,999.32.

The recreational value of the Perch in Oneida Lake and other waters can not be reduced to figures, but everyone who is familiar with fishing by lines in our small lakes and larger rivers knows that large numbers of Perch are caught, and often they prevent disappointment for they frequently bite when other fish do not. They are more easily caught than any of our other fishes sought by anglers. They are acceptable for the table at all times, and furnish much amusement for persons unskilled in fishing and without expensive special equipment for line fishing.

The Perch is of some economic importance through its destruction of other fishes useful to man, or through its competition with these fishes. It has been noted that young Perch destroy the spawn of other fish, including Pike Perch. Embury ('22, p. 5) says they are notorious spawn eaters, and often in the late fall or early winter visit gravel or rocky shoals to feed upon whitefish eggs. Bean ('11, p. 142) says they eat eggs of Lake Trout. While Perch eat other fishes, judging from food studies made they are evidently not of serious importance in this respect, at least in many regions.

In regard to the Perch as a competitor with other fishes with which it is associated, Pearse and Achtenberg ('20, p. 335) say: "The Perch has rivals in each of the habitats where it seeks food, but it is an able competitor of them all. In shallow waters it may capture mollusca as well as the pumpkinseed, littoral plankton as well as the silversides or bream, insects and their larvae as well as the bass, crawfishes as well as the dogfish, small minnows as well as the gar. In the open lake the Perch's chief competitors for food are the cisco and the white bass, but neither of these fishes excels it in ability to strain plankton from the water. In the deeper regions of lakes, the Perch must contend with the vegetarian and bottom-feeding sucker, cottid, and carp, and with the predacious pickerel and lota. The sucker, cottid, and carp are real rivals when it comes to bottom feeding, for they are especially able to take advantage of the nourishment in the bottom mud. They are also better protected, by reason of their size, from the attacks of the predacious deep-water fishes; but their large size, on the other hand, limits their numbers, and they can never compare with the perch in this respect." In Oneida Lake the Perch competes for food with most of the other species there, but it does not seem likely that it seriously interferes with the growth and numbers of any one species, unless it be the Wall-eyed Pike by devouring

its eggs. Possibly the numbers of Tullibees are reduced by the Perch in this way also, but no information on this question was obtained. The great variety and amount of Perch food in the lake (Baker, '18) would make it appear that the Perch does not seriously compete with any other species in its present numbers.

Few of our native fishes are more attractive than Perch and it is often displayed in public aquaria, as at the New York State Fair. Bean ('97, p. 241) says the Perch is a fairly good aquarium fish, though sometimes susceptible to fungus attacks. He has fed the fish hard clams and live Killifish. Hankinson has found the Perch very difficult to transport from Michigan lakes to indoor aquaria. In laboratory aquaria they must be kept in cold, well aerated water.

The Perch is propagated artificially, according to Leach ('27, p. 21), by the following method: Adult fish are procured from market fishermen and allowed to spawn in tanks of running water or in boxes or pens. Sometimes the eggs are collected from bodies of water and are hatched in jars of the kind used for whitefish, or they are placed in wire hatching baskets suspended in streams near the hatchery and fastened to a float. The fish are distributed as fry or fingerlings.

In 1926 the U. S. Bureau of Fisheries distributed 122,501,000 Perch fry and 2,704,400 fingerlings (Leach, '26, p. 331). Perch were distributed by hatcheries of the Bureau of Fisheries of 23 states. From the Oneida Lake hatchery at Constantia, Perch have been distributed as follows, in recent years:

1924: 317,750 fingerlings, Macdonald, '25, p. 80.

1925: 354,500 fingerlings, Macdonald, '26, p. 70.

1926: 360,750 fingerlings, Macdonald, '27, p. 106.

In raising Perch to fingerlings, they are fed liver and sometimes milk curd (Buller, '05, p. 224).

Perch have been planted extensively in Oneida Lake. Bean ('12, p. 201) records 95,000,000 fry planted there in 1911; and 50,000,000 in 1913 (Bean, '14, p. 336). All were obtained from the Oneida Lake Hatchery.

Angling. The many kinds of food of the Perch make it appear that a variety of bait can be used, but there are times when it shows strong preferences. This appears to be correlated with the kind of food it is eating at the particular time. Hankinson has been able to catch Perch through the ice in winter in some waters in Michigan, only by using small minnows as bait; nothing else seemed to entice them. He has also caught them abundantly in certain Michigan Lakes by using earthworms for bait, but on other occasions at the same places although the fish could be seen in abundance in shallow water it was impossible to induce them to touch a worm baited hook. In ponds in the Whitefish Point region of Michigan he found the Perch abundant, but it would not bite on anything except leech bait. With this bait results were excellent. In the stomachs of the Perch thus caught leeches were found in such numbers as to indicate clearly that at that time leeches were their favorite food. Eyes of Perch are the best bait for ice fishing in Oneida Lake. Hankinson found that the Perch caught through the ice were feeding on burrowing May-fly nymphs, and there was a strong resemblance between the dark, food-distended abdomens of these insects and the eyes of Perch. At one time in Lake Michigan Hankinson and a party caught over a bushel of Perch by baiting with pieces of Perch flesh. He has tried this as bait in other places where

Perch were abundant and were biting on worms, but without success. The bait that is most generally successful is the earthworm or "fishworm," with reference especially to the medium-sized Perch, those about 8 to 10 in. long. For catching the much larger Perch of our lakes that dwell in water 20 to 30 feet deep, minnows are commonly used. Hankinson has been familiar with some lakes in Michigan where these larger fish were abundant but were never successfully taken with worm bait. They were caught only by using minnows in deep fishing. The capture of numbers of these large Perch by angling usually requires skill, and sometimes special equipment and experimentation with baits. In some regions Perch are taken with fly or spoon hook, as at Lake Maxinkuckee (Evermann and Clark, '20, p. 425); and grasshoppers and grub worms are sometimes used with success (Jordan and Evermann, '03, p. 366). Forbes and Richardson ('09, p. 278) mention pieces of mussel as good bait, and Kendall ('24, p. 308) found frogs suitable. In Oneida Lake various baits are used. Besides worms, dragonfly nymphs—locally called "bass bugs"—make a very successful bait and give the Perch fisherman a chance at the same time to get black bass, which also take this bait. Mr. C. E. Hunter recommends crickets. When Mayflies were abundant, on July 1, 1916, we knew of six Perch that were caught with such bait, in Oneida Lake. In a mill pond at Hillsdale, Michigan, where Perch were once numerous and seemed very hungry. Hankinson found them at times so blindly attracted by the tackle that they seemed to lose all power of discrimination and would grab any small object thrown to them. On such occasions he has often taken Perch with the unbaited hook.

The tackle used for Perch is of many kinds. In the Great Lakes, Perch are commonly caught by simple lines with or without sinkers or floats, and held from boats or piers. Common string, thread, wrapping twine and fish lines of all kinds may be used when the fish are biting well. Forbes and Richardson ('09, p. 278) relate an experiment made at South Chicago by a laboratory assistant. He used a piece of lath for pole, a line of cotton twine, a small hook, and a bit of pork for his bait. The first Perch caught with this was cut up and used as bait thereafter. Within an hour he had caught 75 more. Goode ('03, p. 7) says that the simplest way to catch Perch is with a boy's standard outfit: a pole, a stout line, a large float, heavy sinker, and a worm or minnow for bait. This he considers effective when the water is muddy and the Perch are numerous and hungry, but "for wary fish in clearer water more delicate tackle is necessary. The line should be fine, and a simple reel may be used; the float should be small and well balanced, and the shot used for sinkers only heavy enough to keep the float steady. The float should be adjusted so that the bait may be suspended about a foot from the bottom, and a gentle motion upwards and downwards may advantageously be employed."

There is considerable sport catching Perch through the ice in winter (see Figures 233 and 234). Only a small hole six inches or so in width need be made, and a line with bait let down to near the bottom. Tip-ups are sometimes employed. In February, 1921, Hankinson visited Oneida Lake to make observations on ice fishing. The season seemed to be an unusually favorable one, and according to a Syracuse paper, "The 1920-21 ice fishing season has been a record breaker in the annals of Oneida Lake fishing." Special trolley cars were then run and often

these were packed with fishermen with market baskets and bags, in many cases filled or nearly so with Perch. The paper stated that no less than a dozen fishermen had taken up quarters at a Brewerton hotel and supported their families on the proceeds of their fish sales. On February 6, 1921, Hankinson counted fifty ice fishermen at Lower South Bay, in his two hour stay. They were fishing in about ten feet of water, mostly about a quarter of a mile out from the south shore. On February 19, 102 anglers, some of whom were women, were counted. Automobiles were being driven over the 14 inches of ice. Holes about a foot in diameter had been dug with spuds. A man was selling minnows, chiefly *Notropis atherinoides*, at 25 cents a hundred. With the minnows the fishermen could get a few Perch and the eyes of these were then used as a better bait. Most of the fishing was being done, as has been mentioned, in about ten feet of water, and only Perch were being taken at this depth. One party of seven people were fishing in deeper water near Dunham Island; they were getting larger Perch but fewer of them. These fish were about a foot in length. One Burbot (*Lota maculosa*) 15½ inches long had been taken, the only fish other than Perch caught by the many fishermen. Evermann and Clark ('20, p. 276) in their discussion of ice fishing in Lake Maxinkuckee, record 72 Perch caught through the ice between December 14 and January 23, 1900-01. Pearse and Achtenberg ('20, p. 301) mention ice fishing in lakes near Madison, Wisconsin, with the use of minnows and Perch eyes as bait.

References. Abbott, '90; Adams and Hankinson, '16; Baker, '16, '18; Bangham, '25; Bean, '92, '97, '02, '03, '07, '09, '09a, '11, '12, '14; Bensley, '15; Buller, '05; Butler, '19; Clemens and others, '23, '24; Cobb, '04; Colbert, '16; Cole, '05; DeKay, '42; DeRyke, '22; Dunning, '84; Dymond, '26; Ellis, '14; Embury, '15, '22, '27; Essex and Hunter, '26; Evermann and Clark, '20; Fisher, '93; Faust, '18; Forbes, '78, '80, '80a; Forbes and Richardson, '09; Fowler, '14; Franklin, '15; Goode, '84, '03; Gorham, '11; Greeley, '27; Hankinson, '08, '10a, '16, '24; Hay, '94; Henshall, '03; Jordan, '82, '05, '25; Jordan and Evermann, '86, '03; Kendall, '24; Koelz, '26; Kreckler, '19; La Rue, '14; Leach, '27, '27a; Lefevre and Curtis, '12; LaRue and others, '26; Lucas, '25; McCormick, '01; Manter, '26; Macdonald, '25, '26, '27; Marshall and Gilbert, '05; Mead, '19; Mearns, '98; Meehan, '13; Milner, '73; Moore, '26; Nash, '08; Needham, '22; Nichols and Heilner, '20; Osburn, '01; Osborn, '11; Pearse, '15, '18, '18a, '21, '21a, '24a, '25; Pratt, '19, '23; Reed and Wright, '09; Reighard, '15; Rhead, '07; Riley, '18; Ryerson, '15; Shelford, '13; Sibley, '22; Smallwood, '14; Smith, '96, '07; Stafford, '04; Surber, '20; Titcomb, '21, '22; Tracy, '10; Triplett, '00; Turner, '20; Ward, '94, '11; Ward and Magath, '16; Ward and Whipple, '18; Wilson, '20, '20a; Worth, '92; Wright, '92; Yorke and Maplestone, '26.

Stizostedion vitreum (Mitchill). YELLOW PIKE PERCH, PIKE PERCH, WALL-EYED PIKE. Oneida Lake is a home for the much prized game and food fish known as the Pike Perch or Wall-eyed Pike (Fig. 231). Here they are quite abundant notwithstanding the excessive fishing for them, and good catches are frequently made. The species is well known to anglers and may be easily identified by the novice by its perch-like form with double dorsal fin, dark, mottled coloration, rough scales and many large, pointed canine teeth. Recent studies of its growth made by Adamstone ('22, p. 77) make it appear that the Yellow Pike

Perch of the Great Lakes and of many of our smaller lakes, rivers and other waters is distinct specifically from the Blue Pike (*Stizostedion glaucum*) of Lake Erie and Lake Ontario. The Wall-eye is a fish that needs protection on account of its desirability and the ease with which it is caught during the spawning time, when it runs up creeks in large numbers and may be taken in quantities by poachers. It is also easily taken by trap nets of the kind often used illegally in Oneida Lake. Game protectors are continually searching for such nets in the lake, which when found are destroyed by burning. Hankinson, on October 3, 1920, witnessed at Maple Bay, Oneida Lake, the discovery of a poacher's trap net by a Game Protector and the lifting of this net from about ten feet of water. In the net were fifteen large Pike Perch, measuring 12 to 20 inches in length. Besides these fish there were two large Rock Bass, a Chain Pickerel (*Esox niger*) 20 inches in length, 12 Common Bullheads (*Ameiurus nebulosus*) and 8 or 10 large Common Sunfish (*Eupomotis gibbosus*).

Breeding Habits and Life History. The Yellow Pike Perch is a migratory species, since the adults run up streams to spawn, but it is evident that it will lay its eggs in lakes if prevented by weather or other causes from entering streams. (Bean, '02, p. 399; Macdonald, '24, p. 98). Evermann and Latimer ('10, p. 134) found the spawning grounds of this species in Lake-of-the-Woods, Minnesota, to be gravel bottom near shore, along the whole shore line. This fish is known to migrate from deep lake water, where it resides in winter, to the shallows of lakes, in spring—even before the ice has left—and very soon enters streams. At Oneida Lake it begins to run usually in early April. Bean ('13, p. 267) gives the spawning date for Scriba Creek at Constantia on Oneida Lake as about April 7, but weather conditions produce many fluctuations, and in some seasons the fish do not enter the streams at all, or do so in very small numbers (Macdonald, '24, p. 98). No nest is prepared by the fish, but the eggs are dropped directly on the bottom in from 3 to 10 feet of water (Goode, '03, p. 16). The fish do not run to headwaters of streams but may spawn anywhere near the mouth where depth and other conditions are favorable. Mr. J. D. Black informed us that the fish spawn in Chittenango Creek, near Oneida Lake, and Hankinson witnessed the spawning act at Constantia not far from the mouth of Scriba Creek. Figure 235 shows the spawning place, just below the weir crossing the stream. The presence of this obstruction probably determined the spawning at this place. The water was about three feet deep with a temperature of about 50° F, free of sediment and with a moderately rapid current. The bottom was of sand and gravel; the width about forty feet. The breeding fish could be seen in the stream near the weir and often about the boulders on the bottom. The males were smaller than the females, being about 18 inches in length, and had the lower, paired fins bordered anteriorly with white, and the lower lobe of the caudal fin white. The females were about two feet in length. They could be readily distinguished from the males by the indistinctness of the white on the tip of the lower lobe of the caudal fin. A typical specimen of each sex was given us by the hatchery men. These are preserved as Collection No. 208. The male measures $17\frac{3}{4}$ inches in total length and the female $23\frac{3}{4}$ inches. The spawning act was observed by Hankinson several times near the weir, in about three feet of water and near the middle of the stream.



Fig. 235. Scriba Creek at Constantia, at breeding time of Pike Perch. Spawning noted at X, which is slightly below the weir and pens. April 22, 1921.



Fig. 236. Fish weir in Scriba Creek at Constantia, N. Y., used for obtaining breeding Pike Perch. April 22, 1921.



Fig. 237. Weir and pens for Pike Perch in Scriba Creek, Constantia, N. Y. April 22, 1921.



Fig. 238. Pike Perch in tub, ready for stripping, Constantia, N. Y. April 22, 1921.

From two to five or six males would gather about a single female near the bottom, and then the whole group would rise to near the surface, all making vigorous bodily movements and agitating the surface. They then would descend as if exhausted. It is probable that eggs and sperms were emitted during this ascent of the compact company but nothing was seen. Surface disturbances similar to those made by the fish observed were frequent further down stream from the weir, and it is likely that these too indicated spawning acts. The observations were made on April 22, 1920, about 2 P. M., with bright sunlight on the stream.

Twenty or more Pike Perch could be seen in the stream from the weir, and it was evident that many more were in the water below; and some were entering the weir. The spawning behavior is similar to that described by Bean ('13, p. 267). He says that the female can readily be distinguished in the water by her larger size and by the fact that she is attended by several males. In spawning, the female rushes up toward the surface but does not come out of the water. The males dart about her with fluttering motions, discharging the milt while the female discharges the eggs. He notes that after this act the female drops back to the bottom, followed by the males.

Some eggs that were obtained at the Hatchery measured $1/12$ of an inch in diameter. They average about 150,000 per quart. The females may contain from 200,000 to 300,000 eggs each (Bean, '02, p. 399). Careful records have been made of the output of Oneida Lake Pike Perch at the Oneida Hatchery and the average number of eggs per fish has been determined to be between 50,000 and 60,000. Leach considers the number of eggs to be about 45,000 to each pound of weight of the fish. The eggs are adhesive and often cling together in masses in hatchery operations. Hatching takes place in seven days at a mean temperature of 57° F, or 28 days at a temperature of 40° F. The fry when hatched are $3/16$ of an inch in length (Leach, '27, p. 13). The fry are active from the time of hatching and soon engage in cannibalism (Buck, '11, p. 286).

The adult fish are commonly about two pounds in weight, in Lake Erie, according to Jordan and Evermann ('03, p. 362), but they may breed when less than a pound in weight (Goode, '03, p. 16). The Yellow Perch is thought to reach a maximum weight of about 50 pounds, but Nichols and Heilner ('20, p. 1) record 40 pounds for the largest one taken.

Adamstone ('22, p. 83) made a study of the growth rate in the Yellow and the Blue Pike Perch, using specimens from Lake Erie. His results showing relation between size and age are here given:

TABLE NO. 12. SHOWING RATE GROWTH OF PIKE PERCH IN LAKE ERIE.

Length of Fish	Weight	Age
5.8 in.....	2 oz.	$2\frac{1}{6}$ years
9.8 in.....	$9\frac{1}{2}$ oz.	$3\frac{1}{6}$ years
11.8 in.....	16 oz.	$4\frac{1}{6}$ years
15.2 in.....	35 oz.	$6\frac{1}{6}$ years
25.0 in.....	172 oz.	$13\frac{1}{6}$ years

Habitat. The adult Wall-eyed Pikes inhabit generally the deeper water of Oneida Lake. In summer they may be found in water from about six to twenty feet in depth, according to testimony of some anglers. They are said to prefer rocky bottoms near vegetation. Fully a half of the lake, mostly in the western part, has water of suitable depth for this fish, and the extensive areas of rocky bottom make conditions favorable for this species. Henshall ('03, p. 160) says this fish prefers rock to gravel bottom. Dymond ('26, p. 79), in writing of Lake Nipigon, says they frequent 10-20 feet of water in early summer, but in late August and in September they migrate to 60-90 feet of water. In Oneida Lake, then, we would expect the fish to move toward the eastern part of the lake where the water is deepest, in late summer and early fall. According to the testimony of Mr. C. E. Hunter, State Game Protector of Syracuse, such a movement does actually occur. He says they are most often caught in June in four to eight feet of water, till about the 20th, when the May-fly flights begin. After that they are taken in deep water only. Smith ('92, p. 208) says for Lake Ontario that Pike Perch (probably referring to both species) are found close to the shore in spring, but by summer they have left the shore region and frequent the shoals of the lake; in fall they seek the deeper water and remain there throughout winter. In small lakes, like Walnut Lake, Michigan, the Wall-eyed Pike evidently lives in the deeper water, but makes excursions at night to the shoals, visiting weedy bays and other situations where it can secure food in the nature of small fish (Hankinson, '08, pp. 183, 193, 214). The pond weed zone (p. 214) appears from collections made to be the favorite habitat of the species in small lakes.

Young Pike Perch from about one to two inches in length were frequently taken in Oneida Lake, but they were not found in numbers at any one place. All taken were from shallow water over clean bottom, either rocky or sandy, and they seem to belong to a rather definite fish association which contains Tessellated Darters, Zebra Darters, cyprinids, and usually Barred Killifish, young Perch and young Common Suckers. Dymond ('26, p. 79) gives similar findings for the young Pike Perch in Lake Nipigon, Ontario. He says the young have been taken on a number of occasions by seine, usually over a sandy bottom, commonly associated with Tessellated Darters, Perch, and the young Common Suckers.

Food. Food studies of the Pike Perch in Oneida Lake were made by Baker ('18, p. 217) from fish collected in deep water by means of trap nets. Three out of 15 specimens examined contained fish. One had a common sunfish four inches long; another, four unidentified small fishes $1\frac{1}{2}$ inches long; and a third had a fish about 4 inches long, also beyond determination. Hankinson and Dence studied the food of the small fish of this species collected from the shallows of Oneida Lake. There were eight specimens from one to two inches in length, collected from six different parts of the lake. Six of them contained food, all of which was fish, but the species represented could not be identified on account of the state of digestion. One Pike Perch (No. 526) had nine small fry in its stomach.

Food studies of Pike Perch have been made from a number of waters other than Oneida Lake. Especially important are those of Pearse for Wisconsin Lakes. His results are here given:

TABLE NO. 13. FOOD OF PIKE PERCH IN CERTAIN WISCONSIN LAKES, AS DETERMINED BY A. S. PEARSE

Publication by Pearse	Locality in Wisconsin	Number of fish studied	Date	Size inches	Fish food contents	Other food
'21a, p. 45...	Lake Geneva....	8	Aug. 13-24, 1920	8½-12	25% (Perch).	.....
'21a, pp. 31-39	Lake Pepin.....	11	June 25-July 10, 1920	13-16½	79%.....	<i>Sialis</i> larvae, 21%.
'21a, pp. 39, 31	Lake Pepin.....	5	July 25, 1920	2 (ave.)	30%.....	Chironomid pupae, 13%, entomostracans, 56%.
'18, p. 275....	Lake Menona...	2	Sept. 15, 1915	17-18	100%.....	.....
'18, p. 275...	Lake Waubesa..	9	Nov. 14, 1915	17½ (ave.)	88.9%.....	<i>Rana pipiens</i> , 11.1%.

Greeley ('27, p. 64) studied the food of seven Pike Perch 13-27 inches long, from the Genesee System in New York State, and found young Perch, suckers and minnows forming about four-fifths of the food, while aquatic insects comprised the remainder.

Evermann and Clark ('20, p. 299) found fish in the stomachs of Pike Perch from Lake Maxinkuckee. Twenty-four were examined in which the food consisted only of fish, but specific determinations could not be made due to advanced digestion. Leech ('27, p. 4) says that the main food of Pike Perch in Lake Erie is the lake shiner, which abounds in these waters, occasionally crawfish in the winter and insects in the warmer months. The shiner referred to is probably *Notropis atherinoides*, and the note on the food evidently applies to both the Blue and the Yellow Pike Perch.

Clemens, Dymond and Bigelow ('23, p. 184; '24, pp. 129-130) made a very careful and thorough study of the food of *Stizostedion vitreum*, based on 78 specimens from Lake Nipigon. Three of the fish were very young, 1⅜-1⅞ inches, and had taken entomostracans of four genera, *Daphnia*, *Cyclops*, *Bosmina*, and *Epischura*. Fish remains were found in two of the pike and Chironomid larvae and pupae in one. Eleven medium-size Pike Perch 12 inches long had been feeding largely on insects; seven had eaten fish, of which one was a Tessellated Darter, one a *Cottus* and sixteen were Nine-spined Sticklebacks (*Pungitius pungitius*). The insects were immature stages of Trichoptera and Ephemerida. The smallest one of the lot, 4¼ inches long, had eaten entomostracans and chironomid pupae. The other 67 fish were more than a foot long, the largest being 22¼ inches. In these, fish was the principal item of food. Ciscoes were present in 24 of the pike. Other fish identified as food of these larger pike were Common Whitefish (*Coregonus clupeaformis*) (in one Pike), Nine-spined Stickleback (*Pungitius pungitius*), Trout Perch (*Percopsis omiscomaycus*), Perch (*Perca flavescens*), Pike Perch (*S. vitreum*), and some cottids.

The Ciscoes, so far as they could be identified from stomach contents, were

Leucichthys xenithicus and *L. nigripinnis*. The insects in these larger fish were chiefly ephemerid nymphs. Dymond ('26, p. 79) evidently refers to these same data but notes a difference in character of food with depth. In shallow water (10-20 feet) the species takes small fishes such as sticklebacks, cottids, darters and young suckers, in addition to ephemerids. In deep water (60-90 feet) it lives almost entirely on young ciscoes. From the Lake Nipigon studies we might surmise that the cisco-like fish of Oneida Lake, the Tullibee, is important to Wall-eyed Pike there.

Jordan and Evermann ('08, p. 362) note the Wall-eyed Pike feeding on crawfish at periods when in shallow water. Bensley ('15, p. 45) records the species eating Perch, suckers, Rock Bass, Mud-puppies (*Necturus maculosus*) and crawfish, in Georgian Bay. Smith ('92, p. 190), in writing of Lake Ontario says the Pike Perch is fond of Alewives, and further (p. 208), that since the introduction of the Alewife the Wall-eyed Pike had apparently increased in size. Observations in 1890 had shown that the Alewife constituted the chief food of the Wall-eyed Pike in the lake, and was undoubtedly the cause of its great fatness. These observations suggest possibilities of studies with a view to introducing Alewives in Oneida Lake. Now this species seems to be very scarce there, but is extremely abundant in Lake Ontario, whence it could be easily carried to Oneida Lake.

The first careful studies on the food of Pike Perch were made by Forbes ('80, p. 35) who, in an examination of the stomach contents of two young fish, 2-2½ inches long, found one minute fish, and some entomostracans (*Cyprididae* and *Daphniidae*). Ten adults were found to have taken only fishes: Gizzard Shad (*Dorosoma cepedianum*), a small sunfish, and a cyprinid, including a Creek Chub (*Scmotilus corporalis*). The specimens of Gizzard Shad were recorded as taken (Forbes and Richardson, '09, p. 273) from one Wall-eyed Pike caught in Peoria Lake, Illinois.

Distribution Records. We made the following collections in shallow water (under 3 feet), mainly with minnow seines: Nos. 400E and 400K, Froher Bay; No. 422K, bay east of Mathews Point; No. 434F, near Norcross Point; No. 441K, Taft Bay; No. 463K, East Potter Bay; No. 464D, stream at East Potter Bay; No. 498I, Messenger Bay; No. 501K, bay west of Lewis Point; No. 522E, Frenchman's Island; No. 526J, near Chittenango Creek; No. 550G, Godfrey Point; No. 552K, West Vienna.

The following were collected in deep and medium deep water, mainly with trap nets: No. 141I, Constantia; Nos. 145, 145D, and 146, Grass Island Bar; No. 342, Constantia; No. 447I, stream entering East Potter Bay; Nos. 2408A, and 2408B, Constantia.

The following specimens were found dead on the lake surface: No. 456G, West Potter Bay; Nos. 560T and 560U, Cleveland.

Market specimens obtained from the Brewerton market are Nos. 2, 3, 359, 601, 627F. Nos. 107 and 149 are collections of stomachs obtained from the same market.

Pratt and Baker made the following collections in deep water (5-15 ft.) with trap nets: Nos. 1205, 1216D, 1264B, 1265B, Dry Land Point; No. 1233A, North Poddygut shoals; Nos. 1247E, 1251D, Muskrat Bay; No. 1268B, Pachings Bar.

Enemies and Disease. Wall-eyed Pike in Oneida Lake appeared to be very free from disease during the time of our field investigations. The fish seen appeared healthy, with bodies well formed. Very few were found dead among the many carcasses of fish of various kinds seen floating or on the shore. In April, 1927, Dence made two visits to the hatchery at Constantia during the height of the Pike Perch spawning season. The tanks were filled to capacity with fish waiting to be stripped. About 5 per cent of the fish contained wart-like excrescences in the skin and on the fins, particularly the latter. The fins of some Pike Perch were literally covered with these growths, which in some cases were also found on the head about the eyes and mouth. In spite of this affliction the fish appeared healthy and were apparently yielding a normal amount of spawn. This disease was found on two specimens (Nos. 146 and 4215) collected from the lake in other years.

The predacious enemies of the species in the lake are probably almost entirely other fishes, although they do to some extent prey upon each other (Clemens and others, '24, p. 129). No definite information was obtained by us on the vertebrate enemies, other than man, of this species, except through observations of Hankinson, who saw many young perch on the spawning beds of the species, and these are known to feed upon its eggs (Bean, '12, p. 201). Pratt ('23, p. 67) reports that eight of the nine Oneida Lake fish examined contained parasites. Of these eight, seven contained *Acanthocephala*, seven contained cestodes, and one contained a single trematode. No nematodes were found by Pratt, but in one fish (No. 498) 1¼ inches long we found a mass of thread-worms or nematodes in the stomach. A large specimen found dead (No. 456) had 15 large leeches in its gill chamber.

While the literature on the Pike Perch reveals names of many parasites, no account has been found of a thorough study of these parasites in the species, although Cole ('05, p. 579) mentions excrescences in the skin of specimens he found in Lake Erie as due to some sporozoan parasite. Whether or not this infested both the Blue and the Yellow Pike is not stated.

Space will permit only a mere mention of the parasitic worms given in the literature on the Pike Perch so far as known to the authors.

TREMATODES

Azygia sp. Pratt, '23, p. 67, Oneida Lake.

Azygia acuminata Goldberger. Pearse, '24, p. 171; Manter, '26, p. 62.

Azygia angusticauda Stafford. Stafford, '04, p. 108; Manter, '26, p. 61.

Azygia longa (Leidy). Pearse, '24, p. 171, as *A. bulbosa*.

Diplostomum sp. Pearse, '24, p. 172.

Centrovarium lobotes (MacCallum). Ward and Whipple, '18, p. 401.

Crepidostomum laurcatum Zeder. Stafford, '04, p. 493.

Gasterostomum pusillum Stafford. Stafford, '04, p. 494.

CESTODES

Bothriocephalus sp. Pratt, '23, p. 67; Oneida Lake.

Bothriocephalus cuspidatus Cooper. Pearse, '24, p. 4.

Proteocephalus sp. Pearse, '24, p. 174.

Proteocephalus ambloplitis Leidy. Pearse, '24, p. 175.

ACANTHOCEPHALA

Necochinorhynchus sp. Pratt, '23, p. 67.

Necochinorhynchus cylindricus (VanCleave). Pearse, '24, p. 80.

NEMATODES

Dacnithoides cotylophora Ward and Magath. York and Mapleton, '26, p. 384.

COPEPODS

Ergasilus centrarchidarum. Evermann and Clark, '20, p. 299.

Argulus sp. Wilson, '04, p. 119.

MOLLUSKS

Lampsilus gluteola, Coker, '21, p. 162; glochidia.

In the literature on Pike Perch are notes on parasites not specifically determined, at least the species names are not recorded. Evermann and Clark ('20, p. 423) found trematodes abundant in the stomachs of Pike Perch from Lake Maxinkuckee examined by them. Ward ('11, p. 227) notes 478 parasitic worms in 18 of these fish; others were not examined. He found 139 cestodes and 333 acanthocephalans. Bean ('07, p. 216) found an eye disease affecting young Wall-eyed Pike in Scriba Creek, a tributary of Oneida Lake, at Constantia, N. Y. The disease also attacked other small fishes, like Trout Perch. Evermann and Clark ('20, p. 299) tell of the abundance of leeches on Wall-eyed Pike at Swanton, Vermont. Here nearly every one of two hundred specimens examined had at least a few leeches somewhere on its body. From the roof of the mouth of a four pound female, forty leeches were taken.

Little concerning the predatory enemies of this species could be found in literature. Cheney ('97, p. 205) says: "At spawning time, the only fish they seem to fear is the real pike, *Lucius lucius*, . . . for this fish will drive them from their bed when the black bass will not." Bean ('12, p. 201) tells of a spawning stream at Constantia being filled with small Perch and minnows which fed on the eggs and fry of Pike Perch, and he believes that the percentage that escaped these depredations was very small. Cole ('05, p. 595) notes the Carp as a possible enemy of Pike Perch, by interfering with its eggs attached to water plants. Bean ('13, p. 274), in writing of the destructiveness of the Lake Lamprey in Oneida Lake, lists the Wall-eyed Pike as a fish attacked by this parasite and ('10, p. 255) mentions that Foreman Scriba, of Constantia Hatchery, in July and August found the lake literally covered with dead fish, most of which were Pike Perch and Ciscoes (Tullibees), and practically all of them bore Lamprey marks.

Economic Importance. A fish of large size with piscivorous habits, when abundant, is likely to affect the other animal life of the body of water in which it dwells in an important way. Fortunately, however, the Pike Perch does not feed extensively, in large natural bodies of water, upon fish directly useful to man. Minnows and other soft-rayed fishes, which are mostly of the "rough" class of fish, appear to be its usual food (Forbes, '80, p. 35; Leach, '27, p. 4). Forbes (l.c.) shows the importance to man of the Pike Perch feeding upon Gizzard Shad. He



Fig. 239. After the eggs and milt have been stripped from the Pike Perch water is added and the mixture is stirred until the fertilized eggs are hardened.



Fig. 240. Towing a crib of stripped Pike Perch to the lake, April 22, 1921. The stripped fish are now emptied into Scriba Creek.

estimates that a single Pike Perch may eat at least 600 of these Gizzard Shad in a year, and he considers it highly important in making this Shad indirectly of value as a food fish for man. Since the shad feeds largely on algae (see also Tiffany, '21, p. 122), these plants are then made available as a food for man through the Gizzard Shad and the Wall-eyed Pike. Gizzard Shad do not occur in Oneida Lake, according to our findings, but minnows and other fishes there, eaten by the Wall-eyed Pike, feed extensively on minute crustaceans, insects, algae, and other organisms not used as human food; and no doubt a relation similar to the one discovered by Forbes in the Illinois River, involving minnows and other non-food fishes, exists in Oneida Lake. Important results would undoubtedly come from an intensive study of the Wall-eyed Pike in Oneida Lake, with particular attention given to its food and that of the fishes it eats. By the same method employed by Forbes, Baker ('18, p. 218) has used the few data on the food of Pike Perch in Oneida Lake and therefrom estimated that 31,200 fish are required to feed the Pike Perch there. He acknowledges the meagerness of his data, and his figures to be but a rough estimate. The abundance of minnows and other fishes that are usually small and otherwise unfit for human food and for sport, and useful only as bait or as aquarium specimens, are in a few cases of considerable indirect value in helping to perpetuate the very desirable Pike Perch in the lake. The invertebrate and the plant life in this water (Baker, '18) both provide abundant food for these minnows and thus become of indirect use to man.

Food studies show that Pike Perch feed upon small Yellow Perch in Oneida Lake and elsewhere and are thus of value in keeping down the numbers of these fish, which are so likely to become superabundant in waters with adequate food for them (such as Oneida Lake), often with a consequent reduction in size so as to be too small to interest the angler. Many of these perch thus become replaced by the larger and otherwise more attractive Wall-eyed Pike. Forbes and Richardson ('09, p. 273) also recognize the Wall-eyed Pike as useful for introduction into waters with small useless fish species.

It is well known that the flesh of Pike Perch is highly palatable and has a high market value. Leach ('27, p. 4) says of the Pike Perch as a table fish: "The smaller fish are delicious, fried, broiled, or boiled, while the larger ones weighing from 5 to 15 pounds, are excellent when baked. The flesh is firm and well flavored, even in the warmest weather. Few fish stand shipment, holding, or freezing better than Pike Perch. It is not so well adapted to salting as some species, but this is not important, as the demand for it is so great that the supply is always disposed of fresh or frozen. The abdominal cavity is comparatively small and the head medium, so that little loss occurs in dressing. The bones are somewhat numerous, but they are generally large and easily separated."

The species is one of the most important commercial fishes of the Great Lakes. Recent figures given by Leach ('27, p. 3) are as follows:

TABLE NO. 14. SHOWING THE NUMBER OF POUNDS AND THE VALUE OF THE PIKE PERCH FROM THE GREAT LAKES REGION IN 1922.

Lake	Pounds	Value
Ontario	153,850	\$29,637
Erie	22,357,996	1,285,399
St. Clair	38,620	5,741
Michigan	132,948	21,185
Superior	23,298	3,268

Figures for New York State alone are, according to Macdonald ('27, pp. 92-93):

Lake	Pounds	Value
Ontario	27,499	\$8,530
Erie	170,915	9,685[?]

The figures for Lake Erie and Lake Ontario given above are partly for the Blue Pike (*Stizostedion glaucum*).

Not only has the Pike Perch high commercial value but it is a species much sought by anglers in portions of the Great Lakes and in numerous inland lakes of the Great Lakes states and elsewhere. So the species has a high recreational value. Many anglers make Wall-eyed Pike their chief objective, but many are taken also by bass fishermen, giving variety to the string of large fish brought in.

Leach ('27, p. 4) says of the game qualities of Pike Perch: "The Pike Perch although capricious, is readily caught with baited hook, artificial fly, spoon, etc., and deserves high rank as a game fish. About 100 tons are taken annually with hook and line through the ice about the Bass Islands, Lake Erie; large quantities are also thus caught near Buffalo, N. Y., in Saginaw Bay, Michigan, and elsewhere."

The Pike Perch does not appear to be decreasing in numbers so fast as many of our other game fishes. Mr. C. E. Hunter, Game Protector, of Syracuse, N. Y., who is very familiar with conditions in Oneida Lake, asserts that the species is maintaining itself well there despite the extensive fishing, including much that is illegal. During each of the past two years the hatchery crew at Constantia have taken enough Pike Perch on about a third of a mile of shoal to obtain around 1900 quarts of eggs. Furthermore the nets probably secure only a small portion of the fish from the fishing area. These facts should give some idea of the vast numbers of Pike Perch that very likely inhabit the several miles of shoals which are said to be equally as suitable for spawning fish as those of Constantia. In some of the larger rivers of the Great Lakes region and undoubtedly elsewhere, the fish has been exterminated or greatly decreased in numbers by contamination by sewage or factory waste. Its habit of running up streams to spawn often exposes it to poisons from such sources. An important reason why the fish is holding its own against so many odds is that it is easily and extensively propagated and planted. The fish are caught for the purpose at the breeding time with nets or weirs. They are

easily stripped, and the eggs can be hatched in hatchery jars of the kind used for whitefish. The success that has been obtained at hatcheries with whitefish and trout is well known. Bensley ('15, p. 46) notes that the eggs of Pike Perch are more difficult to handle than those of whitefish and trout, but on the other hand relatively greater results may be had with little effort and cost. The small size of the eggs permits a jar capacity of three or four times as many as in the case of Whitefish eggs, and the period of operation involves but three or four weeks, the time dependent upon the temperature of the water. Leach ('27, p. 4) says in regard to the success of the culture of Pike Perch: "In spite of the zeal with which it is pursued, on account of its fine food qualities and the ease with which it is captured, it appears to be maintaining its numbers well, a condition that may be attributed, perhaps, to its hardiness and the facility with which it responds to artificial cultural methods." Accounts of the cultural methods used for the species are given by Leach ('27, pp. 4-19), and details should be sought in such special publications. In general, the adults are captured at the spawning time. At Oneida Lake this is commonly about the first week in April (Bean, '13, p. 267), but the time is later with backward seasons. The fish are caught in traps in the form of weirs, like the one used by the Constantia Hatchery, in Scriba Creek (Figs. 236 and 237), or by trap nets placed in the lake. In 1920 when Hankinson visited the hatchery and watched the operations, both methods of catching the fish were being used. The weirs have been abandoned in recent years and the fish are taken entirely by trap nets. In 1927 seventeen of these nets, placed in 4-8 feet of water a short distance from the mouth of Scriba Creek, secured during the height of the season an average of 2000 fish daily. With the present conveniences this is about the maximum number that the hatchery force can strip in a day. There are about four times as many males as females and consequently the milt of three or four males is used to fertilize the eggs of a single female. After the fish are caught they are placed in tubs (Fig. 238) or tanks until they can be stripped. The eggs and milt are received in a wooden bowl and stirred with a feather brush (Fig. 239) to insure fertilization. The eggs are then transferred to the hatchery jars. Some figures as to the output of the Oneida Hatchery at Constantia are here given.

TABLE NO. 15. SHOWING THE NUMBER OF PIKE PERCH FRY PRODUCED AT THE ONEIDA HATCHERY.

Year	No. of fry produced	References
1923	42,100,000	Macdonald, '24, p. 113.
1924	97,700,000	Macdonald, '25, p. 80.
1925	70,200,000	Macdonald, '26, p. 70.
1926	115,200,000	Macdonald, '27, p. 106.

The fry produced are planted in various waters of the State, including Oneida Lake. In 1922, forty million were planted in Oneida Lake (Macdonald, '23, p. 114). From the Oneida Hatchery many eggs are sent to the Caledonia Hatchery for hatching and fry distribution. The St. Lawrence Hatchery also collects eggs

of Pike Perch and hatches fry. These three hatcheries appear to be the only ones in New York State handling Pike Perch.

Results of plantings of Pike Perch are, as with other species, commonly intangible, but the fishing for the species is extensive and since it is holding its own so well, it is probable that the efforts through culture and plantings are giving important results. Bean ('13, p. 268) states that Pike Perch had increased in the St. Lawrence River tributaries; that during the five years prior to 1912, 11,175,000 fry were planted in these streams. Natural spawning probably helps considerably to maintain the Pike Perch in Oneida Lake, but the abundance of small fish that eat its eggs (Bean, '12, p. 201) suggests much uncertainty in the natural process as compared with artificial methods.

Angling Notes. Wall-eyed Pike Fishing in Oneida Lake is considered good by anglers. Large catches are made at the present time, according to information given us by Mr. C. E. Hunter, Game Protector, and others, although success is somewhat sporadic. Cheney ('97, p. 205) notes the erratic nature of the species, but this seems to be due to its moving in schools. We often saw on Oneida Lake numbers of fishing boats congregated, which we were informed contained anglers who were seeking Wall-eyed Pike. The people thus fishing watch each other; and when a pike is seen to have been caught the presence of a school of the fish is suspected and all those fishing in the vicinity now congregate near the spot where the catch was made.

Mr. Hunter informs us that in June the fish are in shallow water (4 to 8 feet), where fishing is usually carried on until the May-fly or "fish fly" flights occur, which is usually in late June or early July. After that, they are caught only in deep water, the deeper the better, according to Mr. Hunter.

In Oneida Lake, Pike Perch are commonly sought by anglers by still fishing or by trolling. By the former method worms, minnows, and dragon-fly nymphs or "bass bugs" are used with success. In trolling, spoon hooks of a variety of kinds, such as "kidney," "skimmers" and "June bug" are used. In deep water fishing, a line with a weight or sinker of about four ounces is dragged at the end of a line. To this is tied, several feet above its sinker, another line a few feet in length with the spoon hook attached. Mr. George Friend informs us that a number 3 spoon hook is best.

The literature pertaining to angling for Pike Perch shows that it is caught by many diverse methods. Henshall ('03, p. 161) notes the importance of using gimp snells instead of gut snells to withstand their sharp teeth. He considers the hours after sunset till dark most favorable, and that night fishing is successful (l.c., p. 162) on account of the nocturnal habits of the fish. In some localities, especially in streams, fly fishing is very successful and attended with considerable sport (l.c., also Rhead, '07, p. 76). Bensley ('15, p. 46) says they bite in early morning and at sundown, in clear waters; but in dark inland waters they may be taken at any time of the day, although better when the light is not intense. Some of the baits recommended are frogs (Nash, '08, p. 91), strips of fish flesh, used in rapid waters and guided near the bottom (Goode, '03, p. 19); and crawfish (Bean, '12, p. 195). Bean ('02, p. 400) recommends minnows that are silvery and mentions the Fallfish as a suitable bait.

The angler's equipment for successful Wall-eyed Pike fishing is diverse. Goode ('03, p. 19) recommends for fly fishing a 5-9 ounce rod, a four foot leader and a bass fly. For still fishing he suggests a twelve-foot bamboo rod with line and reel and a No. 3-0 sproat hook.

In Oneida Lake as well as in other localities winter fishing for Pike Perch is attended with considerable sport, using tip-ups. Goode ('03, p. 20) describes such fishing in Lake Pepin, Wisconsin. Live minnows were used as bait, and holes were made in the ice, from 10 to 31 rods apart. Leach ('27, p. 4) writes of ice fishing in the Great Lakes, already mentioned in this discussion. He says that small minnows are generally used as bait and that the fish are caught near the bottom.

References. Adams and Hankinson, '16; Adamstone, '22; Baker, '16, '18; Bean, '02, '07, '12, '13; Bensley, '15; Cheney, '97; Clemens and others, '23, '24; Cole, '05; Dymond, '26, '27; Evermann and Clark, '20; Evermann and Latimer, '10; Forbes, '78, '80, '88; Goode, '03; Greeley, '27; Hankinson, '08, '10; Henshall, '03; Jordan and Evermann, '02; Kendall, '24; Koelz, '26; Leach, '27; Macdonald, '24, '27; Manter, '26; Nash, '08; Pearse, '18, '21, '23, '24; Pratt, '23; Reighard, '90; Rhead, '07; Shrader and Shrader, '22; Smith, '92, '07; Surber, '20; Stafford, '04; Stranahan, '00; Ward, '11, '12; Ward and Whipple, '18; Wilson, '04; Yorke and Maplestone, '27.

Hadropterus maculatus (Girard). BLACK-SIDED DARTER. Black-sided Darters appear scarce in the region under consideration, since only five specimens were caught. The species is readily distinguished from other darters in Oneida Lake by the series of 7 or 8 large indistinct roundish dark blotches on its sides, and by the ventral median row of enlarged scales, which may be replaced by a naked strip caused by a loss of the scales. The fish grows to a length of 4 inches.

Habitat. One of our five specimens (No. 87) was from a small, short tributary of Chittenango Creek, where the bottom was muddy, with much aquatic vegetation; the other four (Nos. 456, 522) were from rocky or gravelly bottom of the shallows of the lake. Bean ('03, p. 508) says: "It prefers clear streams with gravelly bottom and is more active in its habits than most of the other darters, not concealing itself so closely under stones." Shelford ('13, p. 95) lists it with other darters that live among stones, and says that they are all positively rheotactic and apparently lie parallel with the current.

Forbes and Richardson ('09, p. 286) found it about equally abundant in smaller rivers and in creeks, but rarely occurring in the larger rivers or in bottom-land lakes and ponds. Hankinson ('13, p. 111) found it about Charleston, Illinois, in rivers and large creeks, but scarce in small creeks. Osborn ('01, p. 91) finds it in clear streams on gravelly bottoms, in Ohio. Jordan and Evermann ('96, p. 1033) say that the species is abundant in clear, gravelly streams, but is not abundant in small brooks.

Food. Little published information on the food of this darter is obtainable. Forbes and Richardson ('09, p. 287) consider its food to be miscellaneous aquatic insects. Turner ('21, p. 54) mentions that in eleven Ohio specimens, may-fly nymphs, chironomid larvae, *Corixa* nymphs, copepods, fish remains and silt were found in the enterons. Greeley ('27, p. 64) found six midge larvae (*Chironomidae*)

and a small May-fly nymph in the stomach of a small Black-sided Darter under two inches long, taken July 7, near Mt. Morris, N. Y.

Distribution Records. The five specimens were taken as follows: No. 87, small tributary of Chittenango Creek near the lake, 1 fish; No. 456, West Potter Bay, 2 fish; No. 522, Frenchman's Island, 2 fish.

Economic Relations. The species appears to be of little economic value. It may be used as bait, in the absence of anything better (Evermann, '01, p. 350). As an aquarium fish, it is unsurpassed by any of its kindred, according to Bean ('03, p. 508), who says that its sudden and remarkable changes of brilliant colors during the breeding season render it unusually attractive. Jordan and Copeland ('96, p. 25) say that "It is especially desirable for aquaria, being hardier than any other fish as pretty, and prettier than any other fish as hardy."

References. Bean, '03; Evermann, '01; Forbes and Richardson, '09; Greeley, '27; Hankinson, '13; Jordan and Copeland, '96; Jordan and Evermann, '96; Nash, '08; Osborn, '01; Shelford, '13; Turner, '21; Ward, '11.

***Percina caprodes zebra* (Agassiz).** MANITOU DARTER. (See Figure 232.) Darters are familiar to bait fishermen and others who observe or collect small fish, because of their habit of resting apparently motionless on the bottom, propping themselves up anteriorly with their large pectoral fins, and when disturbed, darting to another place where they instantly come to rest. This habit is well described by Jordan and Copeland ('96, p. 20), in recalling boyhood days: "You tried sometimes to put your finger on a little fish that was lying apparently asleep, on the bottom of a stream, half hidden under a stone or a leaf, his tail bent around the stone as if for support against the force of the current. You will remember that when your finger came near the spot where he was lying, his bent tail was straightened, and you saw the fish again resting, head upstream, a few feet away, leaving you puzzled to know whether you had seen the movement or not."

The Manitou Darter and the Log Perch (*Percina caprodes*), are the largest of the darters, sometimes reaching a length of 8 inches. Manitou Darters are very common in Oneida Lake, but those that we took were rather small, all under 4 inches. These were from shallow water, but possibly larger individuals dwell in the deeper parts of the lake. Notwithstanding the small size of our specimens they were usually much larger than other darters taken. The relatively large size, the broad head, the pig-like snout and the vertical elongated bars or spots on the sides of the body make it easy to distinguish this darter from others in Oneida Lake.

Breeding Habits and Life History. Detailed observations were made on the breeding habits of the Log Perch (*Percina caprodes*) by Reighard ('13a, p. 104; '15, p. 238). His description is here given: "During the eleven days beginning June 29, the fish were breeding on the pure sand bottom near the camp in water from four to twelve inches deep. About 150 fish were under observation. Sexes are distinguishable when the fish are at liberty by the darker coloration and by the behavior of the male, and in captivity by the larger anal fin of the male.

"The breeding males are found in groups of 15 or less. Among these are a few females, but most of the females are seen waiting in deeper water or about the borders of the group. When a female enters the group she is at once pursued

by one or more males, usually by many. She continues for some time to flee in a tortuous course back and forth through the group in its neighborhood. The female finally settles to the bottom and a male takes position over her with his pelvic fins clasping her head and his tail at the side of hers. A rapid vibration of the tail, pectoral and pelvic fins of both fish then follows and lasts about four seconds. This sends backward a whirl of sand and excavates a little pit in the sand beneath the fish. During this time, the eggs are emitted and fertilized and are usually buried in the sand, some in the pit, others behind it. Each egg is weighted by a coating of adhering sand grains. The spawning pair is usually enveloped by a group of supernumerary males, which are attempting to supplant the pairing male. When the spawning is completed, the spawning fish leave the pit or at least the female does so. She repeats the spawning in many other pits. When the spawning is finished at a pit the supernumerary males (and perhaps the pairing male) at once surround the pit and devour such eggs as they can get. The eggs were found in their stomachs. The eggs and young receive no care from their parents, but these, when the spawning period is ended, go into deeper water and are not again seen."

Eigenmann ('95, p. 252) found the species spawning on May 30 in northern Indiana; a single ripe female was taken by him on June 25.

Habitat. Our many collections of this species make it very evident that in Oneida Lake it prefers stony bottoms, at least in shallow water. The carpet of algae that grows over stony bottoms in places seems to favor it. The fish, was, however, found very generally distributed on the shoals of the lake, often on sandy bottom and sometimes on muddy bottom. Mr. Dillenbeck informed us that it also occurs in deep water, wherever the bottom is stony. We found them in streams near the lake, and they were abundant in Black Creek at Cleveland (No. 480) and in Douglas Creek (No. 413), in June, 1916. They are frequently found in lakes where they are more frequently seen than other darters (Evermann, '01, p. 350). Reighard ('13a, p. 104; '15, pp. 238, 242, 245) records them from Douglas Lake, where they are rarely seen and where they appear to live in the deeper waters. Some were noted in three or four feet of water, near vegetation, and were found breeding in June on sand bottom in a foot or less of water. Reighard considers the fish to be a part of the vegetation community. McCormick ('92, p. 29) finds it very abundant among the stoneworts that carpet Sandusky Bay and Put-in-Bay. Forbes and Richardson ('09, p. 282) in Illinois found it relatively most abundant in medium sized rivers, and in creeks next. In larger rivers, lakes, sloughs and ponds it was much less common. They consider it not very particular as to choice of localities and found it entering turbid waters freely; but it is not a swift water species, according to these writers.

Food. Forbes (Forbes and Richardson, '09, p. 283; Forbes, '80, p. 28) found about one-third of the food to be crustaceans, mainly Entomostraca, and the remainder chiefly *Chironomus* larvae, May-flies, *Corixa*, mollusks, and algae. Baker ('16, p. 194) examined the stomach contents of six Manitou Darters from Oneida Lake, finding about two-thirds of the food to be crustaceans (Amphipods, Copepods, Cladocera and Decapoda); the remainder was insects (*Chironomus* larvae, and Odonata nymphs), mollusks, filamentous algae and macerated matter. Reighard

('15, pp. 224, 239; '13a, p. 104) and Ellis and Roe ('17, p. 71) found them eating the eggs of their own species; and when suckers were feeding upon their eggs on the spawning beds in Douglas Lake, groups of the darters were about them. Ten of these Log Perch had from 8 to 20 eggs of their own species in their stomachs. Bensley ('15, p. 47) gives the food of *Percina caprodes* as minute *Chironomus* larvae, small amphipods, crawfish, and Entomostraca. Evermann and Clark ('20, Vol. 1, pp. 300, 430) found insect remains with beach fleas, *Bosmina*, *Daphnia* and *Chironomus* larvae. Cole ('05, p. 600) found it had eaten Carp eggs. Pearse ('18, p. 271) lists the food matter found in 27 of these darters, averaging 3 inches in length: fish eggs, 27.8%; insect larvae, 45.5%; insect pupae, 3.7%; adult insects, 1.7%; amphipods, 6.6%; entomostracans, 0.3%; leeches, 2%; plant remains, 3.4%; algae, 1.7%; silt and débris, 5.7%. Clemens ('24, p. 140) shows by table very completely identified food objects of five Log Perch. Chironomids constituted the principal food, but other aquatic insects and many entomostracans also had been eaten. Turner ('21, p. 43) tabulates his findings from the studies of 133 examples of *Percina caprodes* and the subspecies *zebra*. Copepods and other entomostracans had been taken abundantly and appear to be the principal food, at least of the darters under two inches in length. Larvae of midges and other insects, amphipods and worms were eaten in important numbers. Fish remains were found in one little darter about 1½ inches long. Turner's general conclusion concerning the species is given on p. 55, as follows: "Of the eleven species examined, *Percina caprodes* most nearly meets the specifications of generalization in its food habits. The periods of infancy and of youth are well marked and the period of maturity is marked by an omnivorous habit. It would also be expected that a fish with a generalized food habit would find survival easy and would therefore be abundant and uniformly distributed. All these requirements are met, indeed the distribution of *Percina* was identical with that of the perch in many places." DeRyke ('22, p. 39), in summarizing food studies of 51 *Percina caprodes* from Winona Lake, Indiana, says that the species is apparently one of the most regular feeders among all the species examined in Winona Lake, with little or no change of food as the fish increases in size. The principal food he found to be small Crustacea, principally amphipods and Cladocera; larvae of *Chironomus* and Trichoptera; and ephemerid nymphs. Greeley ('27, p. 64) found seven crustaceans (*Gammarus*), three caddice worms, seven midge larvae, and an unidentified insect pupa in the stomach of *Percina caprodes*.

Distribution Records. The late summer collections from the shallow water of the lake in 1915 contained few of these darters. The following, made at that time, contained each but one fish, except No. 86 which had four: No. 76, mouth of Scriba Creek; No. 77, Bullhead Bay; No. 78, Baker Point; No. 86, Poddygut Bay; Nos. 90, 91, Maple Bay; No. 100, Walnut Point; No. 102, Ladd Bay; No. 137, Long Island. One was taken at this time in Chittenango Creek (No. 88); and five from Scriba Creek (No. 75). In October, 1915, five were taken. These are in collections No. 309, Lower South Bay, and No. 314, Brewerton. Most of these darters were taken in June and July, 1916, when they were abundant in shallow water. The following collections made at that time contained them: No. 400, Froher Bay; No. 401, Billington Bay; Nos. 403, 404, Shackelton Point; No. 413,

Douglas Creek; No. 416, Lakeport Bay; No. 422, Mathews Point; No. 427, Dakin Bay; No. 434, Norcross Point; No. 441, Taft Bay; No. 447, East Potter Bay Creek; No. 448, near Taft and Bernhard Bay; No. 453, Bernhard Bay; No. 456, West Potter Bay; No. 460, Black Creek; Nos. 463, 464, East Potter Bay; No. 483, Fairchild Bay; No. 498, Messenger Bay; Nos. 501, 502, Lewis Point; No. 507, Upper South Bay; No. 517, Sylvan Beach; No. 522, Frenchman Island; No. 523, Short Point Bay; No. 539, Dunham Island; No. 547, Chittenango Creek; No. 550, Godfrey Point; No. 552, West Vienna; No. 553, West Vienna Creek; No. 593, North Bay Creek; No. 599, Brewerton; No. 607, Shaw Bay; No. 610, Lower South Bay.

Enemies and Disease. A Manitou Darter (No. 414) was taken from the stomach of a large Rock Bass that had been caught by hook in Douglas Creek, on June 22, 1916. A leech was found on the tail of one fish (No. 507). One (No. 550) was taken which had soft yellowish swellings at the base of some of its fins. Other diseased specimens were Nos. 413 and 599. McCormick ('92, p. 29) found Log Perch to form the bulk of the fish remains that he saw among the tern nests on Rattle Snake Island in Lake Erie, July 13, 1891.

Ellis and Roe ('17, p. 69) give an account of the eggs of *Percina caprodes* being devoured by suckers (*Catostomus commersonii*) in Douglas Lake, Michigan. Fifteen of these suckers were opened, and an average of 500 Log Perch eggs were found in them. Evermann and Clark ('20, p. 430) says the Log Perch is infested to some degree with trematodes, which form small black spots in the skin, but that it is not so susceptible to these parasites as are some of the other darters. The Red-breasted Merganser (l.c., p. 496) and the Common Pike, *Esox lucius* (Greeley, '27, p. 62) have been known to feed on this darter.

Economic Relations. In some localities this darter is large enough to be used as a pan fish, but we obtained no evidence that those in Oneida Lake are ever so used, or that it is ever used as bait there. Mr. Dillenbeck tells us that they are a nuisance because they take worms from hooks when these happen to rest on the bottom; this he says may occur in water as deep as 18 feet.

Angling. Manitou Darters and Log Perch are frequently caught by hook in some regions, but are probably of little interest to any except juvenile fishermen. Forbes and Richardson ('09, p. 283) say that it is probably the only one of our darters definitely known as an anglers' fish.

References. Abbott, '84, '01; Baker, '16; Bensley, '15; Clemens, '24; DeRyke, '22; Eigenmann, '95; Ellis and Roe, '17; Evermann, '01; Evermann and Clark, '20; Forbes, '80; Forbes and Richardson, '09; Greeley, '27; Jordan and Copeland, '96; Jordan and Evermann, '96; McCormick, '92; Reighard, '13a, '15.

***Boleosoma nigrum olmstedii* (Storer).** TESSELLATED DARTER. These Darters were very abundant and very generally distributed in the shallow waters of Oneida Lake. They were found under a variety of conditions, but evidently preferred gravelly or rocky shoals, especially those with some algae on the bottom. They are easily distinguished from the other darters in the lake by their slender form, light color (except for the highly pigmented breeding males), the W-shaped markings on the sides of the body, and the protractile premaxillaries.

Breeding Habits and Life History. Eggs of this species were found June 27, 1916, in the west part of Potter Bay. They were on the under side of a large piece of tin that lay on the gravelly bottom in two feet of water. A heavily pigmented male guarded the eggs boldly. When the tin was removed, he remained about the spot where it had lain, and when driven away he would promptly return. The tin was placed in a dip-net and lowered to the bottom near the male fish which came at once under the net. A number of these dark-colored breeding fish were seen and taken in the lake at about this time, but careful search did not reveal any other eggs. There were very few stones that could be used to shelter eggs on the shoals, for all were driven firmly into the bottom soil, evidently by ice. Possibly the fish attach their eggs to upper surfaces of stones, as Seal ('92, p. 9) found them doing in an aquarium. The account of the breeding of this species by Seal (l.c.) is here quoted: "The eggs were deposited on the under surfaces of stones, or on the backs of them, where one leaned against the ends or back of the tank, or against another stone, in a single irregular layer over an area of about 1x3 inches. They were about the size and appearance of those of the common sunfish and were deposited in the same manner. The great activity and brilliant coloration of the male, which is ordinarily one of the most sober-hued of the darter family, differing but little from the female, were very conspicuous.

"The spawning was effected by passing up and down over the surface chosen until all the eggs were extruded and adhering to the stone. The fish undoubtedly pair, for, although all the males would be in a state of great excitement and would endeavor to join in the operation, they were invariably driven away by the successful male, who would dart at them furiously with open mouth and fins quivering with excitement, the colors glowing with increased brilliancy and intensity. The male guards the eggs incessantly and drives every fish from their vicinity during incubation, retaining the brilliant color until that duty is over."

The largest Tessellated Darters caught by us in Oneida Lake were $2\frac{3}{4}$ inches long. They are said to grow to a length of $3\frac{1}{2}$ inches (Jordan and Evermann, '96, p. 1027). Wright and Allen ('13, p. 6) give as the breeding place of the Johnny Darter (very probably including this species), gravelly shallows under stones or overlapping edges. Bean ('97, p. 187) tells of certain eggs attached to the lower sides of stones having been found in Frederick Creek. These were hatched and found to be Johnny Darter eggs.

Habitat. These darters were numerous in the shallow water about Oneida Lake on mud, gravel, and sand bottom and also in streams near the lake. Our collections make it appear that they have preference for sandy bottoms. In other regions this darter is often found over muddy bottoms. Wright ('18, p. 543), from his studies of tributaries of Lake Ontario, says the species is not restricted to a gravelly bottom and swift current, as many other darters are. Fowler ('06, p. 301) notes such a preference in streams. Abbott ('84, p. 359) found Olmsted's Darters wandering indefinitely up-stream, and no puddle appeared to be too small for them. They were in greatest abundance in a little shallow just off the main channel of a small creek where there was no perceptible current, and the bottom was of mud with a thin stratum of sand over it. In this sand they left impressions as they moved about, by which they could be tracked. Sometimes this darter buries itself in the sand, leaving only its eyes visible (Nash, '08, p. 96).

Food. Baker ('16, p. 196) found the food of three Oneida Lake examples of this species to be crustaceans (Entomostraca and amphipods), Diptera, gastropods and algae. Abbott ('84, p. 359) writes of their being carnivorous as crocodiles, with the digestion of an ostrich, and tells of their predilection for quiet byways in streams. This seems to be a result of the habits of other animals which bring their food to these retreats to enjoy it at leisure and always leave fragments for the benefit of the darters. "Indeed," says Abbott, "these fish do not wait always for the crumbs that may fall from some mightier creature's table, as I have often seen them crowd around some happy turtle that had brought a fish or a fragment of flesh to this shallow in order to dine in peace. The little darters, however, did not wait to be invited, but standing at the other end of the fish or flesh, would give it little tugs and nips while the turtle was busily engaged in biting off larger and larger mouthfuls. These darters are the most persistent egg-hunters anywhere to be found, and in spite of the vigilance of the parent fish, will dart in and out and swallow the eggs that have been laid and placed with so much care. Many fish so place their eggs that they are not accessible to the darters; but when laid in the sand, as the sunfish do, or among loose pebbles only, the darters can readily find them, and they quickly devour all they discover." We noticed one of these darters near Dunham Island about the eggs of *Hyborhynchus notatus* that were being guarded by a male of this species. The darter appeared to be after the eggs, but the attending fish was very successful in keeping it away.

Distribution Records. The following collections gave examples of this species: No. 75, Scriba Creek and Frederick Creek; No. 83, Johnson's Bay; No. 86, Paddygut Bay; No. 88, Chittenango Creek; Nos. 90, 91, 92, Maple Bay; No. 99, Walnut Point; No. 120, Big Bay; No. 124, Fairchild Bay; No. 142, Frederick Creek; No. 305, Brewerton; No. 309, Lower South Bay; No. 400, Froher Bay; No. 401, Billington Bay; Nos. 403, 404, Shackelton Point; No. 406, Leete Island; Nos. 425, 427, 428, Dakin Bay Creek; No. 434, Norcross Point; No. 441, Taft Bay; No. 447, East Potter Bay; No. 448, near Taft Bay; No. 453, Bernhard Bay; No. 456, West Potter Bay; Nos. 459, 463, 464, East Potter Bay; No. 470, Cleveland Bay; No. 483, Fairchild Bay; No. 491, Three Mile Bay; Nos. 500, 501, Lewis Point; No. 507, Upper South Bay; Nos. 512, 515, Fish Creek; No. 517, Sylvan Beach; No. 522, 543, Frenchman Island; No. 526, Maple Bay; Nos. 530, 529, Dunham Island; No. 550, Godfrey Point; No. 552, W. Vienna; No. 553, West Vienna Creek; No. 559, Willow Point; No. 585, Lower South Bay; No. 591, Sylvan Beach; No. 593, North Bay; No. 594, West Vienna; No. 599, Brewerton; No. 603, Fairchild Bay; No. 604, Fairchild Bay and Wedgeworth Point; Nos. 605, 607, Shaw Bay; No. 611, Lower South Bay; No. 613, Brewerton; No. 614, Norcross Point; No. 4272, Messenger Bay.

Enemies and Disease. Embury ('10, p. 630) found a specimen of this darter in the enteron of a King Eider (*Somateria spectabilis*) that had been captured on Seneca River, N. Y., November 26, 1909. Evermann and Kendall ('96, p. 603) report at least 30 of these darters in the stomach of a Burbot (*Lota maculosa*) 14 inches long. Abbott ('73, p. 83) tells of finding them captured by crawfish, under stones where the darters had sought concealment. The caudal half of a Tessellated Darter was found in the stomach of a pike, *Esox lucius*, 4½ inches long, caught in

Fish Creek, a tributary of Oneida Lake (No. 515). In our collections we found two diseased specimens (Nos. 403, 413). One had small oblong whitish objects in its abdomen, which could be seen through the ventral body wall.

Economic Relations. If this darter is as destructive to the eggs of other fishes as it appears to be, it may because of its large numbers and general distribution be a serious factor in reducing the numbers of sunfish, black bass and other useful species that place their eggs on the bottom in Oneida Lake. Their small size, skulking ways and protective markings would make them capable of easily evading fish guarding the eggs.

References. Abbott, '73, '84; Baker, '16; Bean, '97; Embury, '10; Evermann and Kendall, '96; Fowler, '06; Jordan and Evermann, '96; Ash, '08; Seal, '92; Wright, '18; Wright and Allen, '13.

Poeciliichthys exilis (Girard). IOWA DARTER. The Iowa Darter was taken in a few places in Oneida Lake and in streams connected with it. It is a small species, seldom over two inches in length. Its most distinctive characteristic is its short dorsal fins, the anterior having from seven to ten spines, and the posterior nine to eleven soft rays. In form it is much like the Tessellated Darter, but it lacks the W-shaped markings on the sides possessed by this minnow, and is ordinarily darker in color. The young of the two species are often hard to distinguish, but in the Iowa Darter the dark bars confined to the sides of the body, with the alternating brownish blotches, are usually evident and diagnostic.

Breeding Habits and Life History. Breeding males of this species are among the most beautiful of our darters. They have the color pattern accentuated, and latent bright reddish brown spots and similar colors on the sides of the belly, and one on the distal half of the spiny dorsal fin. A good figure of one of these darters is given by Forbes and Richardson ('09, opp. p. 306). Bensley ('15, p. 48) describes these breeding males more in detail as follows: "The anterior dorsal fin has the basal two-thirds deep blue green, darker between the rays. There is a narrow band of blue at the margin of the fin, separated from the basal band by a stripe of orange. Sides with angular cinnamon blotches to and along the base of the anal. Basal membranes of the posterior dorsal, caudal and anal with diffuse greenish."

Bensley (l.c.) finds the breeding season in Ontario to be the latter part of May and June. He says the eggs are deposited on stones, especially in sheltered crevices, often in water only a few inches deep; and the fish are commonly in groups, in which there is a lively competition among the males for the possession of the females. Jaffa ('17, p. 72) found males in full breeding dress with milt flowing freely when touched, and also ripe females, in streams three to four feet deep near Boulder, Colorado, from April 22nd to June 1st. In the laboratory he found the incubation period of the eggs to be from eighteen to twenty-six days, and the young at hatching to be 3.4 mm long. Evermann and Clark ('20, Vol. 1, p. 443) found females, April 27, 1901, at Lake Maxinkuckee, which were full of spawn.

Examples of this species taken by us in Oneida Lake were small, under two inches in length, except one specimen which was taken at Dunham Island (No. 539); this was about two and one-half inches long.

Habitat. Judging from the conditions under which the twelve Iowa Darters in our collection were taken, the fish is more of a lake than a stream fish, for none was taken in streams except right at the mouths where lake conditions were an influence; and they seem to prefer sandy bottom and to tolerate areas with considerable vegetation.

Hankinson ('16, pp. 125, 131-136, 151) found the Iowa Darters common in small lakes and sluggish streams in the marshes along Lake Superior in the Whitefish Point Region of Michigan. None was found in Lake Superior, although their habitats were freely connected with it, and they were found in quiet beach pools close to it. They seemed to have strong preference for muddy bottoms of bays and other places where the water was seldom disturbed. Many of them could be seen here resting or moving slowly, leaving little trails behind them. At Walnut Lake, Hankinson ('08, p. 216) found Iowa Darters rather common in shallow water, in spring. In early April, shortly after the ice left the lake, these fish were especially common where a marsh bordered the lake, being found among the sedge roots there. After July 1, none was found on the shoals. They evidently go to the deeper water in late summer, in Walnut Lake.

Jaffa ('17, p. 72), in writing of the habitat of this fish in Colorado, says: "The darters were especially fond of pools where the bottom of the stream was covered with a heavy slime and masses of rotting vegetation, which had to be removed before the fish could be captured. When disturbed, the darters, which could be seen resting on top of this slime, burrowed into the soft débris by a series of quick movements of the pectoral and ventral fins. This preference for the deep pools at this time seemed to be correlated with the breeding activities of this species, as it was found usually under pebbles in swiftly running water and in shallow riffles during the fall, winter and early spring." Ellis ('14, p. 109) remarks on the hardiness of this species, since it has been taken farther north and west than any other darter and at the same time as far south as Arkansas.

Evermann and Cox ('96, p. 421) say: "This species is pre-eminently an inhabitant of small lakes, ponds, isolated overflow pools along river courses, and of the sluggish, grassy creeks of the prairie region. Wherever we found a small pond or slowly flowing stream with plenty of aquatic vegetation and a more or less muddy bottom, there we found this little darter in larger numbers."

Food. Six Colorado specimens were studied by Ellis ('14, p. 109). These had been eating caddice fly larvae, *Chironomus* larvae, gastropods, annelids, and entomostracans. Mosquito larvae also are eaten to some extent by this species (Evermann and Clark, '20, p. 302). The food of twenty-eight Iowa Darters from Lake Nipigon in Ontario is recorded by Clemens ('24, p. 144), with detailed identifications of most food objects found. Chironomidae formed 30% of the food, and other aquatic insects were present in about the same amount. Small mussels (*Sphaeriidae*) constituted 11% of the food. Pearse ('18, p. 259) gives a summary of the food of five Iowa Darters from Wisconsin Lakes, as follows: chironomid larvae, 21%; beetle larvae, 16%; amphipods, 58%; snails, 3%; oligochaete worms, 1.6%; débris, .4%.

Distribution Records. One Iowa Darter was taken in each of the following collections, except No. 522, in which four were taken. All were caught between

August 31, 1915, and October 16, 1916. No. 76, mouth of Scriba Creek; No. 90, Maple Bay at mouth of Chittenango Creek; No. 105, Muskrat Bay; No. 309, Lower South Bay; No. 428, Dakin Bay; Nos. 447, 463, East Potter Bay; No. 522, Frenchman Island; No. 539, Dunham Island; No. 622, Brewerton.

Enemies and Disease. Faust ('18, p. 195) records a trematode parasite, *Stephanophiala parionis* (O. F. M.), on this darter. Evermann and Clark ('20, Vol. 1, p. 443) say that this fish more than any other species of fish in Lake Maxinkuckee, is susceptible to diplostomiasis, characterized by small round black spots in the skin, each representing the cyst of a distomid which is said to reach its mature form in the stomachs of water birds. These darters were occasionally found in the stomachs of other fishes.

References. Bensley, '15; Clemens, '24; Ellis, '14; Evermann and Cox, '96; Faust, '18; Forbes and Richardson, '09; Hankinson, '08, '16; Jaffa, '17; Pearse, '18; Reighard, '15.

Catnotus flabellaris (Rafinesque). FANTAIL DARTER. Five of these darters were taken, one from the lake and four from Frederick Creek. This creek was the only place studied where the species was at all common, though it may have been more plentiful in the lake without coming to our notice, especially if, as appears true, it has strong preference for rocky bottoms, where it could easily escape the net as well as observation. The marked activity of the fish makes it a difficult one to capture on broad lake shoals where it is not easily cornered. The taking of only a single individual in Oneida Lake, then, is not significant, and probably simply means that the species is not abundant there.

The Fantail Darter is readily identified by the relatively very low anterior dorsal fin, averaging about half the height of the posterior one; and in the male this first dorsal fin has spines that end in fleshy expansions—a condition not found in any other of our darters.

Breeding Habits and Life History. Wright and Allen ('13, p. 6) give as its breeding place, "Gravelly shallows, on stones." Forbes and Richardson ('09, p. 314) took four females apparently nearly ready to spawn, in May. Greeley ('27, p. 65) found the eggs of this darter on the lower surface of a stone, about 400 in number, placed side by side in a round patch. A male darter $2\frac{1}{4}$ inches long, probably the parent, was found under the stone. The eggs were $\frac{3}{32}$ of an inch in diameter. The locality was Phillips Creek, Allegany County, N. Y., and the date, June 25, 1925. The water temperature was 68° F. He found two other nests of the species, one on June 22, in Cryder Creek, Allegany County, in which the egg mass was about two days from hatching and was placed under a stone in swift water, with an attending male; temperature of water 66° F. The other was found in a tributary of Angelica Creek, of the Genesee System, July 9. Here, too, a male was with the eggs, which were hatching. The temperature of the water was 76° F.

Habitat. Wright and Allen ('13, p. 6) consider its habitat to be riffles and shallows of gravelly creeks. Bean ('03, p. 520) says that it abounds in clear rocky streams. According to Jordan and Evermann ('96, p. 1097), "It lives in swift waters, and its movements in the water are more active than those of any other species." Forbes and Richardson ('09, p. 314) find it to be a darter mainly of the smaller streams, usually inhabiting the swifter creeks and brooks, although

occasionally taken in rivers and lowland lakes. Greeley ('27, p. 64) from his extensive survey of the Genesee stream system in New York State, notes that it shows a preference for the smaller streams there. Shelford ('13, p. 95) notes it as a darter that is especially likely to be found among and under stones, or in algae which cover the rocks. Meek ('88, p. 314) states that it frequents shallow running water, especially if it is clear and the bottom of the stream is rocky. Jordan and Copeland ('96, p. 31) say of its habitat and its relation to it: "It carries no flag, but is colored like the rocks, among which it lives. The Fantail Darter chooses the coldest and swiftest waters."

Food. Forbes and Richardson ('09, p. 314) give the results of the examination of six specimens which had eaten *Chironomus* larvae, May-fly nymphs and copepods. Jordan and Copeland ('96, p. 30) write: "Hardiest, wiriest, wariest of them all, it is the one most expert in catching other creatures, and the one which most surely evades your clutch, he leads an active predatory life. He is a terror to water snails and caddice worms, and the larvae of mosquitoes." Turner ('21, p. 51) records the food of 68 specimens. May-fly nymphs predominated; the rest of the food was midge larvae, amphipods, and beetle larvae. He found that the fish from Lake Erie and Ohio streams agreed closely as to the nature of their food, but the stream fish lacked amphipods. The stomach contents of one fish about 2½ inches long, as found by Greeley ('27, p. 65), were three small midge (*Chironomidae*) larvae.

Distribution Records. No. 142, Frederick Creek, September 8, 1915, four fish, average 2½ inches; No. 456, West Potter Bay, June 27, 1917, one fish, 1¾ inches.

Economic Relations. This fish undoubtedly has the same bait-value as other small darters, namely, that it is useful in the absence of anything better (Evermann, '01, p. 350). Bean ('03, p. 520) says that it is very active and tenacious of life and is an excellent species for the aquarium.

References. Abbott, '01; Bean, '03; Evermann, '01; Forbes, '80b; Forbes and Richardson, '09; Greeley, '27; Fowler, '06, '11; Jordan and Copeland, '96; Jordan and Evermann, '96; Meek, '88; Nash, '08; Shelford, '13; Turner, '21; Wright and Allen, '13.

***Micropterus dolomieu* Lacépède. SMALL-MOUTHED BLACK BASS.** Both species of black bass thrive in Oneida Lake, notwithstanding the excessive fishing for them there. The extensive shallow waters furnish an extensive breeding ground for the species, while food in the form of small fish and crawfish is abundant. Along the shore may be found, associated with minnows and other small fishes, the young of Small-mouthed Black Bass. No doubt with proper regulation of fishing Oneida Lake would soon harbor large numbers of black bass, and good catches made in the proper way at the proper times would be the usual results. Conditions (except overfishing) seem to be especially favorable for this bass in Oneida Lake, and every effort should be made to maintain this highly desirable species.

Breeding Habits and Life History. Like other centrarchids this species is a nest builder. The male cleans bottom areas with sweeps of his tail. He brings

females to this nest and spawning takes place. He guards the nest and accompanies the young after hatching until they are an inch or more in length, when the little fish scatter and lead their independent lives. Our work in Oneida Lake was begun too late in the season for observations on the breeding of the bass. Young fish about an inch in length (No. 529) were found by us July 10, 1912, in large numbers scattered over the shallows at Dunham Island. It is probable that these fish were about a month old, and that the parent fish had spawned near the middle of June. The species spawns in spring and early summer, on rising temperature. The water should be about 64° F, according to Beeman ('24, p. 94), who notes that 60° delays spawning, and it ceases below this temperature (p. 102). Reighard ('06, p. 9) says the females spawn at the temperature of 62° F. Nash ('08, p. 88) considers May and July to be the months for spawning in Ontario, and this is probably the time in most of New York State also. Tracy ('10, p. 119) notes that in some parts of its range the species may spawn as early as March.

The nest building, so far as observations show, is done entirely by the male fish, which at the beginning of the spawning season begins to search for a nesting place by nosing around on the bottom to find a gravelly spot (Reighard, '06, p. 8). This bottom testing is an important factor in selecting the nesting site. The depth of water varies. Beeman notes ('24, p. 95) the range to be from 2-12 feet. Forbes and Richardson ('09, p. 265) give the usual depth as three feet, and Evermann and Clark ('20, p. 413), six feet for Lake Maxinkuckee. The bottom should be stony, although the fish will use vegetation patches for supporting the eggs, as does the Large-mouthed Bass (Beeman, '24, p. 95).

The nest is circular in form, varying from two to four feet in diameter, according to Beeman ('24, l.c., p. 95). Wright ('92, p. 454) says the nest is twice the length of the fish in diameter. It takes the male from about 4 to 48 hours in its construction, according to Forbes and Richardson ('09, p. 265). Cheney ('97, p. 179) found that the fish works only when the water maintains a temperature of 65°-66° F for most of the day, but Reighard ('06, p. 9) notes the temperature to be somewhat below 60° when the male begins nest building. After selecting the nesting site, the male fans away the loose bottom material until he gets the stones perfectly clean. He also loosens the material with his mouth (Reighard, '06, p. 9) by rooting about in the gravel, often roiling the water considerably. The soil so loosened is swept away with the fins and tail of the fish. Following nest building, spawning takes place. Females gather in the vicinity of the nest, whereupon the male rushes out and attempts, often unsuccessfully to drive one into the nest. If she breaks away he will drive her back. According to Beeman ('24, p. 96), this may be repeated several times, the female each time remaining a little longer.

When the female is finally ready to spawn, there is a marked change in her appearance. The dark mottlings on her body become very prominent, due to the ground color becoming much paler than usual. It is only at the spawning time that there is a prominent sexual difference as to colors. But close observation will show a red spot on the iris of the male, which is not ordinarily present in the

female (Reighard, '06, p. 11). At the spawning time the females may also be told from males by their thicker bodies, caused by the enlarged ovaries. The dark areas are also intensified, so that during sexual excitement the female may appear much darker than the male (Reighard, '06, p. 11).

During these changes the female swims slowly in a circle or floats motionless, and every two or three minutes rubs her belly against the stones with a deliberate bending of the body to one side and then to the other, and the male bites the female frequently though gently, on the opercle, cheek and corner of the mouth. This act is interpreted by Reighard (l.c., p. 20) as a stimulus for the emission of the eggs. During the emission of the eggs, to quote Reighard: "The two fish lie side by side on the bottom. The female is turned partly on her side so that her median plane forms an angle of about 45° with the plane of the horizon. The male remains upright with his head just back of the pectoral of the female or opposite it." The male is quiet during the process while the female exhibits certain peculiar fin movements. The eggs are emitted at periods when the female is with the male in the nest. Reighard (l.c., p. 12) noted four such periods occupying from 4-6 seconds each and separated by periods of about 30 (22-45) seconds. The female he observed remained two hours and twenty minutes with the male in the nest, and when she departed the male pursued her, but returned to care for the eggs, which meanwhile had become adherent to the bottom stones of the nest (Fig. D, opp. p. 12, Reighard, '06). At all times the male stayed by the nest and cared for the eggs by fanning them with his pectorals. Frequently he made short excursions in circles in the immediate neighborhood as if searching for enemies. Beeman ('24, p. 97) says: "The male hovers almost constantly over the nest. All intruders are immediately driven away. Solicitude and care of the nest, and the future development of the fry is an example of parental care and protection worthy of imitation." The male readily pairs with another female that may approach the nest, the eggs being deposited with those already laid. Beeman (l.c.) noted that the time in which the male shows a disposition to spawn with different females varies from 30 to 36 hours; and that he appears to be able to fertilize the eggs of at least three females.

A female may spawn in more than one nest (Reighard, '06, p. 12). Ordinarily a male spawns with but one female at a time, but Beeman ('24, p. 99) describes a case of a male spawning with two females in the same nest at the same time, with an alternation of the egg-laying periods, and both females leaving at about the same time after their eggs had been laid.

The male guards the eggs until they are hatched. If another fish approaches too near he attacks it, and, according to Reighard's observations, the intruding fish will invariably flee (l.c., p. 14). Beeman ('24, p. 98) mentions males fighting over females, and such fighting ensues generally when there are too few females to the number of males in a breeding pond. Lydell ('04, p. 42) also notes fighting of male fish especially when nests are close together, as they are likely to be in a small body of water, and gives an instance where a male was killed and its nest destroyed by the attack of ten or more other males.

The fry when hatched lie on the bottom for a time, among the stones, and then rise and school, but soon scatter. The attending male remains on duty till

the young are ready to scatter, that is, when they are about $1\frac{1}{4}$ inches in length (Reighard, '06, p. 14).

The number of young produced through the efforts of a single male varies. Beeman ('24, p. 97) found by actual count 10,868 fry from one nest, and gives instances where larger numbers must have been produced. Forbes and Richardson ('09, p. 266) give the number of eggs as 2,000 to 10,000 per individual. The number of mature eggs found in the ovaries of two female bass studied by Reighard ('06, p. 21) was 3,664 and 5,440 respectively. The time of hatching of the eggs varies with the temperature. Lydell ('04, p. 40) found the time to be five days at 66° F, and the young would swarm up from the bottom in 12 to 13 days. Beeman ('24, p. 102) says that complete development, that is, up to the time the fry are ready to rise from the nest, requires about 14 days at temperatures from 64°–70° F, and if it is as low as 59°–60° the time will be about 21 days.

The rate of growth of the species varies with food, temperature and other factors. Forbes and Richardson ('09, p. 206) quote Tisdale, who gives the growth rate as 3 pounds in six years, and a half pound a year till they weigh six pounds. Embury ('15, p. 227) records growths in length as follows: $2\frac{1}{2}$ –3 inches in 5 months; 4–5 inches in a year; and 7–8 inches in two years. The maximum size reached according to Nichols and Heilner ('20, p. 1) is 9 pounds, with a length $24\frac{1}{2}$ inches. Cheney ('97, p. 178), however, gives 10–11 $\frac{1}{4}$ pounds as the size of some of these bass taken near Glens Falls, N. Y., and Henshall ('03, p. 10) evidently refers to this same record. Nash ('08, p. 88) says its maximum weight in Ontario waters is about six pounds. The fish matures when of rather small size, when about two years of age and from 8–12 inches in length (Wright, '92, p. 455).

Habitat. This bass thrives best in clear and cool waters over a rocky and sandy bottom. Waters that are supplied by springs, or cold, clear streams seem especially favorable (Forbes and Richardson, '09, p. 265; Henshall, '03, p. 8, and others). It commonly avoids sluggish or muddy water. Reighard ('15, p. 234) notes its absence in water deeper than 45 feet in Douglas Lake, Michigan; that is, it does not occur below the thermocline there. In Oneida Lake the extensive areas of rocky bottom in both deep and shallow water offer one feature of its favorite habitat; the water is also clear and for the most part without dense vegetation. The preference for rocky bottoms may be due to the presence in such places of the favorite food of this species, which is crawfish, for Baker ('18, p. 194) notes that the young crawfish prefer rocky bottom in Oneida Lake. He did not find crawfish in water deeper than $3\frac{1}{2}$ feet, and it is known that the bass are most abundant in this water zone at least during the daytime. But we obtained few data on black bass in the deeper parts of the lake or concerning their daily migrations.

An intensive study of the species in Oneida Lake would be worth while. The young fish under two inches in length were numerous in the lake, but not in any one locality. They were very generally distributed in shallow water and usually over rocky or sandy bottom, and were usually either very close to shore or to the margins of vegetation. At no time were they in schools. The largest number were seen and taken along the west side of Dunham Island on July 10,

1916 (No. 529F). Here the water was clear and shallow, with gravel and cobble, and there were a few patches of water willow (*Dianthera*) and filamentous green algae about which they dwelt (see Fig. 209). In few cases did we find the fish over mud bottom. Our observations were thus in accord with those of Wickliff in Lake Erie ('20, p. 364).

In winter Small-mouth Black Bass go to deep waters and lie about rocks, ledges, or roots and the like, in a semi-dormant manner and evidently do not take food (Beeman, '24, p. 93; Henshall, '03, p. 8). The adults come to shallow water in the spring to breed, as heretofore noted, and preference is given to areas with stumps, large rocks and similar objects which shield the nest on the shore side (Lydell, '04, p. 39). During the summer Bensley obtained evidence of the non-migratory nature of the species ('15, p. 44), by tagging 100 individuals. Seven were taken after 4-30 days of liberty, and all were found in the neighborhood of the place where they were liberated. Belding ('26, p. 79) shows a familiarity with the Small-mouthed Black Bass in 269 lakes in Massachusetts and has classified these lakes as to their productive capacity for this species. In 49 of them the species thrives especially well. From his study of these lakes and undoubtedly from other data he concludes concerning the habitat of this species, as follows: The area of a good lake should be at least 50 and preferably over 100 acres. The average area of the 49 favorable lakes was 185 acres as compared with 90 which did not produce many of these fish, which had an average of 85 acres. The depth, he concludes, should be not less than 20 feet, and preferably over 30 feet. A depth sufficient to give a thermal stratification seems to be favorable. As to other conditions, Belding writes: "Swampy or dark colored, muddy waters and excessively muddy bottoms should be avoided and clear or turbid, light colored waters selected. Too little or scanty vegetation is unsatisfactory and excessive vegetation such as is found in shallow warm water lakes is unsuitable. The character of the shores and the presence or absence of inlets or outlets have no bearing on the suitability for this species."

Food. Little has been known of the food of this species in a definite way until Pearse published the results of his studies in Wisconsin Lakes ('18, '21, '21a). This was followed by thorough studies of the young Small-mouthed Black Bass in Lake George by Moore ('22), and of the young fish in Lake Erie by Wickliff ('20). It has been known that the little bass found along shore feed upon insects, and that the very young advanced fry eat abundantly of entomostracans. Hatchery men have known the importance of furnishing these fish with such food (Lydell, '04, p. 43). In regard to the feeding of the young fish on entomostracans, Beeman ('24, p. 105) says: "When abundantly supplied, they simply gorge themselves. I have no doubt that a young, healthy bass $\frac{3}{4}$ of an inch in length consumes several hundred Crustacea daily. . . . When the work of feeding begins, there is no letup." The large bass, it has been generally known, feed upon crawfish and thrive best where these exist. But insects and fish, it has been observed (Bean, '03, p. 489), also form an important part of the food of the adult. The results of examination of stomach contents of individuals of this species two inches in length are given below in tabular form.

TABLE NO. 16. SHOWING THE RESULTS OF FOOD STUDIES OF YOUNG SMALL-MOUTHED BLACK BASS UNDER TWO INCHES (50 MM) IN LENGTH

Authority	Place and time of collection	Number	Entomostraca	Chironomids or midges	Other aquatic insects	Other food
Forbes, '80, p. 46	Illinois.....	7	5%.....	4%.....	Ephemero- nymphs, 28%; odonate nymphs, 11%; <i>Corixa</i> , 51%.	.....
Wickliff, '20, p. 366	Lake Erie shallows, Ohio	305	Copepods and Cladocera eaten by most fish; over 90% of food in some.	Larvae and pupae abun- dant as food; in some 30%- 50%.	Ephemero- nymphs, about 13% of food.	Fish, about 22% of food; often 30%.
Pearse, '18, p. 266	Lake Mendota, Wis., Aug. 20, '14.	8	Cladocera, chiefly.	Larvae and pupae; adult <i>Corethra</i>.	.....	Oligochaete worms, 8.6%.
Pearse, '21, p. 265	Green Lake, Wis., Aug., 1919.	6	Cladocera, about 60%.	Larvae and pupae.	Mayfly nymphs.	Plant remains, algae.
Pearse, '21a, p. 36.	Wisconsin Lakes.	3	Cladocera, about 1-10%.	About 50%.	<i>Corixa</i> , 16.7%.	Fish, 6.7%.
Moore, Emme- line, '22, p. 53	Lake George, N. Y.	107	Cladocera abundant as food in most of the fish.	Abundant; all stages.	Ephemero- nymphs; and odonate nymphs; Trichoptera larvae.	Fish remains in one bass. Miscellaneous insects, amphi- pods, algae.
Greeley, '27, p. 63	Genesee River System, N. Y.	1	Phyllopods, copepods.	Larvae.	Ephemero- nymphs; other Diptera.	.....

After they have increased in size to more than about two inches there seems to be a rather sudden change in their food and food habits. Fish two or three inches in length eat entomostracans in relatively small amounts, but take insects of many kinds. It was observed in Oneida Lake that these larger young bass did not frequent the open shallows so much but remained about vegetation patches in deeper waters where insects were more likely to be found. A table showing important findings from food studies of Small-mouthed Black Bass two or three inches in length here follows:

TABLE NO. 17. SHOWING THE RESULTS OF FOOD STUDIES OF SMALL-MOUTHED BLACK BASS TWO TO THREE INCHES LONG

Authority	Place and time of collection	Number	Entomostracans	Crawfish and other crustaceans	Insects	Vertebrates	Other food
Forbes, '80, p. 46	Illinois.....	10	4%.....	.....	<i>Culicids</i> , 1%; <i>Corixa</i> , 82%; muscids, 4%; dytiscids, 2%.	Minnows, 5%.	.....
Wickliff, '20, p. 366	Lake Erie, Ohio	8	.....	Crawfish, 45%.	Chironomids, all stages, about 20%.	Fish, about 50% of food.	.....
Pearse, '21, p. 265	Green Lake, Wis.	3	Cladocera, 65% in two fish.	Hyaella.	Chironomid larvae, 35%; ephemero- nymphs; beetle larvae.	.....	.....
Moore, '22, p. 53	Lake George, N. Y.	7	Present.....	Amphipods...	Midges; odonate nymphs; miscellaneous insects.	Fish re- mains.	Hydrach- nids, algae.

Lydell ('04, p. 43)) notes that the water-boatmen or corixids are eaten by young bass of this species as they grow older. Greeley ('27, p. 63) reports on fish from the Genesee System, 2-2½ inches long, as eating numerous midge larvae.

When the Small-mouthed Black Bass become larger than about three inches, crawfish and fish become the most important food, although insects and entomostracans are not neglected, as is shown below in a tabular résumé.

TABLE NO. 18. SHOWING THE RESULTS OF FOOD STUDIES OF SMALL-MOUTHED BLACK BASS LARGER THAN THREE INCHES IN LENGTH

Authority	Place and time of collection	Number	Entomostracans	Crawfish and other decapods	Insects	Vertebrates	Other food
Forbes, '80, p. 46	Illinois.....	10	.....	Crawfish, 62% in fish over 4 inches; amphipods, 65%; isopods, 14%.	Odonata nymphs.	<i>Percina caprodes</i> ; <i>Noturus flavus</i>.	.....
Reighard, '15, p. 235	Douglas Lake, Mich., August	8	<i>Leptodora</i>	Crawfish in five stomachs.	.....	Leopard frog, shiner.	.....
Pearse, '18, p. 266	Lake Monona, Wis.	4	.....	.....	<i>Corixa</i> ; <i>Chironomus</i> larvae; ephemerid nymphs.	Minnow, <i>Lepomis incisor</i> .	Algae; other plant remains
Pearse, '21, p. 265	Green Lake, Wisconsin, from 40-50 ft. water.	2	.....	.....	Grasshopper.	Perch (50% in one bass).	.....
Pearse, '21a, p. 45	Lake Geneva, Wis.	21	Cladocera, few.	20.6%.....	43%.....	33%.....	.....
Pearse, '21a	Lake Pepin, Wis.	12	5.7%.....	9.1%.....	29.8%.....	Fish, 56.5%	.....
Pearse, '21a, p. 49	Lake Michigan	2	.....	.....	.....	Fish, 98.5%	Plants, 1.5%.
Greeley, '27, p. 63	Genesee River System, N. Y.	13	.....	56%.....	Terrestrial insects, 1.4%; aquatic insects, 24.2%.	<i>Eupomotis gibbosus</i> ; <i>Hyphantelium nigricans</i> ; minnows.	.....

Distribution Records. We made the following collections in shallow water (up to 3 feet), mainly with minnow seines: No. 75, Scriba Creek; No. 76, Constantia; No. 77, Bullhead Bay; No. 78, Baker's Point; No. 86, Paddygut Point; No. 90, near Chittenango Creek; No. 92, Maple Bay; No. 142, Frederick Creek; No. 309, Lower South Bay; No. 314, Brewerton; No. 498, East Messenger Bay; No. 500, bay west of Lewis Point; No. 529, West Dunham Island; No. 539, North Dunham Island; No. 585, Lower South Bay; No. 591, Sylvan Beach; No. 594, stream at West Vienna; No. 604, near Wedgeworth Point; No. 144, Grass Island Bar, taken with a trap net in deep water; No. 4170, Sylvan Beach, September 9, 1927.

Pratt and Baker made the following collections in deep water, with trap nets mainly: Nos. 1227A and 1333H, north of Paddygut shoals; No. 1268A, Pachings Bar.



Fig. 241. Drained Small-mouth Black Bass breeding pond. Shows gravel piles used by the fish for nests. Oneida Hatchery, Constantia, N. Y.



Fig. 242. One of the stone piles for Small-mouth Black Bass nest. Sept. 9, 1927.



Fig. 243. Another stone pile in bass pond bed, Oneida Hatchery, showing gravel sorted by breeding fish. Sept. 9, 1927.



Fig. 244. Screen used about nests of Small-mouth Black Bass at Oneida Hatchery, Sept. 9, 1927.

Nos. 1200A and 1200B, Davison's Landing, were collected in shallow water with minnow nets.

Enemies and Disease. The Small-mouthed Black Bass taken in Oneida Lake appeared quite free from disease. The fish were rugged and mostly without blemish. One fish (415) showed evidence of parasites. Pratt ('23, p. 66) reports on four fish examined which were rather heavily infested with trematodes, cestodes, and Acanthocephali; but he found no nematodes. The trematodes belonged to one species, *Crepidostomum cornutum* (Osborn). The Acanthocephali were of the genera *Neoechinorhynchus* and *Echinorhynchus*.

The literature on the species shows that it has a good many enemies in the form of parasites. Riley ('18, p. 3) found about 60% of these bass infested with cestodes and other worms, in Bass Lake, Minnesota. Fungi readily attack their eggs (Beeman, '24, p. 103) and constitute an important obstacle to hatching them in ponds.

A list of the more important parasitic worms that have been found in Small-mouthed Black Bass is here given:

CESTODES

Proteocephalus ambloplitis (Leidy). Marshall and Gilbert, '05, p. 519; LaRue, '14; Cooper, '15, p. 177; Faust, '18, p. 189; Pearse, '24, p. 175; Moore, '26, p. 139.

Proteocephalus pearsii LaRue. Bangham, '25, p. 256.

Triacnophorus nodulosum Pallas. Pearse, '24, p. 176.

TREMATODES

Azygia tereticolles. Marshall and Gilbert, '05, p. 519.

Azygia loossii Marshall and Gilbert. Pearse, '24, p. 171.

Clinostomum marginatum Osborn. Smallwood, '14, p. 13; Riley, '18, p. 2; Pearse, '24, p. 72; Bangham, '26, p. 120.

Cryptogonimus chyli Osborn. Bangham, '26, p. 118.

Crepidostomum cornutum (Osborn). Faust, '18, p. 189; Bangham, '26, p. 119; Pearse, '24, p. 172.

Diplostomulum volvens (von Nordmann). Ward and Whipple, '18, p. 411.

Diplostomum cuticola. Diesing.

Aucryoccephalus sp. Cooper, '15, p. 190; Bangham, '26, p. 117.

Microphallus opacus Ward. Pearse, '24, p. 173.

ACANTHOCEPHALA

Echinorhynchus thecatus Linton. Pearse, '24, p. 179; Bangham, '26, p. 124; Van Cleave, '19, p. 6.

Pomphorhynchus bulbocolli Lindins. Van Cleave, '19, p. 6.

Neoechinorhynchus cylindratus (Van Cleave). Bangham, '26, p. 125; Pearse, '24, p. 180.

NEMATODES

Spinitectus gracilis (Ward and Magath). Pearse, '24, p. 179.

LEECHES

Placobdella montifera Moore. Pearse, '24, p. 181.

COPEPODS

Ergasilus centrarchidarum Wright. Evermann and Clark, '20, p. 298.

Atheras ambloplitis Killicott. Pearse, '24, p. 182; Evermann and Clark, '20 p. 298.

Atheres micropteri Wright. Pearse, '24, p. 182.

The fry of the Small-mouthed Black Bass before they leave the nest are subject to the attacks of various predators. Meehan ('13, p. 23) notes that sunfish (Bluegills) and even young bass of larger size attack the fry at this critical period. Bean ('92, p. 117) gives as other enemies of this species, crawfish, birds, frogs and snakes; and ('12, p. 204) he mentions the presence of a Fish Hawk about the bass ponds at the Oneida Hatchery at Constantia. Pearse ('21a, p. 44) notes Yellow Perch eating Small-mouth Black Bass.

Economic Importance and Culture. The Small-mouthed Black Bass is even more of a favorite with the discriminating angler who fishes primarily for sport than is the Large-mouthed Bass, but very commonly little thought is given as to which one of these two desirable species is present. The ordinary bass fisherman is satisfied with either. The Small-mouth is commonly of smaller size and is more apt to be found in streams, and in clearer, weed-free water of lakes, where fishing is more of a pleasure than where vegetation is abundant. There is a common impression that the Small-mouth is gamier than the Large-mouth, but Henshall ('03, p. 34) says, after his experience of nearly forty years, covering all sections of the country, that "where the two species coexist there is no difference in their game qualities," and that the one is equal to the other in gaminess when exposed to the same conditions. The flesh of the Small-mouthed Bass is generally considered superior for the table. The habitat differences undoubtedly account for the usual absence of the "weedy" taste so often present in the flesh of the Large-mouth Black Bass. Henshall ('03, p. 15) considers the flesh of but one fresh water fish to be better, and that is the Whitefish of the Great Lakes. He describes the flesh of bass as "white, firm, and flaky, with a fine savor, and a juicy, succulent quality that is lacking with most other fresh water fishes."

This bass is readily established in new waters, and with the other species it has been introduced into Germany, France, and the Netherlands. In Germany it has become permanently established (Henshall, '03, p. 7). Belding ('26, p. 79) states that this species was introduced into Massachusetts in 1850, where it is now present in 269 lakes. Both species have been introduced into many waters of the Pacific Coast region and other waters of the West (Smith, '96, p. 442). In many waters of New York State this bass has been established where it was formerly absent or very scarce (Bean, '03, p. 488), for example at the south end of Cayuga Lake (Reed and Wright, '09, p. 400). In stocking waters with this bass, the forms already present should be given careful attention. Where crawfish are numerous the other fishes of a body of water are not likely to be seriously disturbed, for the bass prefers these crustaceans to fish as food (Henshall, '03, p. 6). Crawfish can therefore be planted in some cases to increase the number of bass and divert them from destroying other fishes (Cheney, '97, p. 178).

The culture of Small-mouthed Black Bass is attended with considerable success, but the fry or fingerlings to be planted must be reared by pond culture, allowing the parent fish to spawn and to attend the eggs and young as in nature. The fish can not be stripped successfully, so jars and troughs of the hatchery can not be used. It is necessary to construct ponds on the hatchery grounds and have bottoms and depth of water suitable for their nesting. Ordinarily piles of gravel are placed here and there on the bottom (Figs. 241, 242, 243) and the fish select them for their nests. The nests should be screened (Fig. 244) with uprights placed on the shore side, so that the fish will not see moving objects along the shore. Success is attained by constructing nesting boxes (Lydell, '04, Plate 8; Reighard, '06, p. 44). These must be properly spaced to prevent the nesting fish from disturbing one another, and at the same time to economize bottom area (Lydell, '04, p. 42; Beeman, '24, p. 98). The fry when hatched have to be removed immediately before they scatter (l.c., p. 104). The securing of breeding fish is sometimes difficult, but they may be kept in ponds and fed liver and minnows (Lydell, '04, p. 41).

The species is planted as fingerlings, raised from the fry stage. To this end entomostracans, especially *Daphnia*, must be present in the rearing ponds (Lydell, '04, p. 43; Beeman, '24, p. 104). Sometimes this food is sufficiently abundant in the hatchery ponds, but it may need to be collected from other waters. Beeman (l.c.) has been able to secure an abundance of food for young bass by using a plankton net attached to a motor boat.

Some figures showing the output of this species by the Oneida Hatchery at Constantia are given in recent volumes of the State Conservation Commission and are as follows:

- 1924. Fry, 147,650; advanced fry, 17,300; fingerlings, 21,700 (Macdonald, '25, p. 80).
- 1925. Fry, 197,500; advanced fry, 84,000; fingerlings, 29,300 (Macdonald, '26, p. 70).
- 1926. Fry, 305,500; fingerlings, 53,800 (Macdonald, '27, p. 106).

Angling Notes. The methods for capturing Small-mouthed Black Bass with lines are diverse and similar to those employed for the Large-mouth. It is, however, more often sought in streams by means of fly casting—a kind of fishing very much preferred by many anglers to that of casting from a boat about lily patches, or to still fishing with minnow bait in weedy coves for the Large-mouth. The gameness of this fish is well known and is described in detail by Henshall ('03, p. 14) who, in comparing the bass with other fishes on the hook, says that the black bass exhibits, if not intelligence, something akin to it in its strategical manoeuvres, as in bounding into the air to free itself from the hook, in making efforts to maintain a slack line, and in attempting to wind the line about roots or other objects. In Lake Maxinkuckee, Indiana, where both species of black bass are present, the best fishing season for the Small-mouth is July and August, while that for the Large-mouth is September (Evermann and Clark, '20, p. 410). The Small-mouth Bass can be caught in this lake almost the year around (l.c., p. 409), and minnows are the best bait. Grasshoppers are recommended for bait in August and early September. Late in the fall, in October and November, trolling with a

live minnow is very successful. A heavy sinker is used and the minnow is dragged near the bottom. Spoon, spinner, and fly are occasionally used. Rarely crawfish make good bait at Lake Maxinkuckee. Sometimes the bass are here caught through the ice.

In Oneida Lake the Small-mouthed Bass is commonly caught by still fishing, with minnows or large nymphs of dragon-flies as bait. The dragon-fly nymphs are sold, sometimes at the rate of four cents each, to bass fishermen. Bensley ('15, p. 44) notes the erratic nature of this species as a game fish, and speaks of it as sometimes biting promptly and vigorously the moment the bait is in the water, while at other times it is wary. Places where on some occasions the fish occurs in abundance seem at other times apparently to be abandoned. Cheney recognizes ('97, p. 176) this peculiarity when he says, "The fly or the bait that may lure black bass one day may be ignored the following day, when all conditions of wind and water seem to be similar."

References. Baker, '16; Bangham, '25, '26; Bean, '92, '02, '03, '10; Beeman, '24; Belding, '26; Bensley, '15; Bower, '96; Cheney, '97; Clemens, '24; Cooper, '15; Embury, '15; Essex and Hunter, '24; Evermann and Clark, '20; Faust, '18; Forbes and Richardson, '09; Goode, '87, '03; Greeley, '27; Henshall, '03, '19; Jordan and Evermann, '96, '03; Jordan and Stapleton, '13; Kendall, '13, '24; LaRue, '14; Lydell, '04, '26; Loudon, '10; Macdonald, '26, '27; Manter, '26; Marshall and Gilbert, '05; Mather, '86; Meehan, '13; Mitchill, '15; Moore, '26; Nichols and Heilner, '20; Needham, '22; Osborn, '11; Pearse, '18, '21, '21a; Pratt, '23; Reed and Wright, '09; Reighard, '06, '08, '15; Riley, '18; Sibley, '22; Smallwood, '14; Smith, '96, '07; Surber, '13; Titcomb, '22; Tracy, '10; Turner, '20; Van Cleave, '19; Ward, '94; Ward and Whipple, '18; Wilson, '19, '20; Worth, '10; Wright, '92; Wright and Allen, '13.

Micropterus salmoides (Lacépède). **LARGE-MOUTHED BLACK BASS.** This bass (Fig. 230) is sufficiently abundant in Oneida Lake and of sufficient size to attract many anglers in the bass fishing season. Good catches are said to be frequent. The species is held to be most plentiful in the shallower, western part of the lake, where aquatic vegetation is most abundant. The name "Oswego Bass" ordinarily is given to this species.

Breeding Habits and Life History. It has not been possible for us to study the Large-mouth of Oneida Lake during its breeding season, so that no definite information on its spawning and nesting there have been obtained. On June 18, 1921, three days after the legal season on black bass opened, Hankinson examined carefully the rush-covered shallows all along the south shore of Lower South Bay. Breeding conditions favorable for the Large-mouth appeared to exist there, but no nesting fish were seen. Some small areas that looked much like nests of this species, were found, and it is probable that these were their used nests.

On June 30, 1916, a large family of very young Large-mouthed Bass was seen in Fairchild Bay. A hundred or more were caught (No. 482). They measured $\frac{3}{4}$ of an inch in length and were probably about 2 weeks old (Bean, '03, p. 492). No parent was seen with them, but they were about the size at which

parental attention ceases (Reighard, '06, p. 35). It is thus evident that important breeding activities may extend to the end of June.

Much has been written on the life histories of black bass, but the two species are often treated together, which is unfortunate since there are evidently important distinctions between the two as to breeding. Published statements on the life histories are frequently very general and based on meager data. Little seems to be known as to the breeding time of the Large-mouthed species. Henshall ('17, p. 74) notes the breeding of black bass in early spring, the time differing in different localities. Goode ('03, p. 58) remarks that the date does not vary much with latitude. Richardson ('13, p. 414) found nests at Havana, Illinois, April 26 and May 18. Forbes and Richardson ('09, p. 269) give the breeding season as May to June. Evermann and Clark ('20, p. 417) found the species spawning in Lake Maxinkuckee from about the middle of May to the 30th, on which date they found about a dozen nests. Tracy ('10, p. 120) and Bean ('03, p. 492) both consider the spawning time as April to July. Bensley ('15, p. 41) found nests in the Georgian Bay region in early June. Hankinson ('08, p. 214) at Walnut Lake found the first nests of this bass on May 16.

As to breeding conditions, Reighard ('06, p. 15) found nests close to shore in ponds with dead leaves, water plants and sandy gravel areas. Richardson ('13, p. 414) found nests in water from six inches to two feet deep, in growths of flags and smartweeds. Bensley ('15, p. 41) found eggs placed on deposits of detritus on swamp bottom. Hankinson ('08, p. 214) found nests on shoals in from 1 to 2½ feet of water, in growths of bulrushes and water-milfoil. The maximum depth for nesting is unknown, but Evermann and Clark ('20, Vol. 1, p. 417) found nests in about six feet of water.

The nest is a simple affair, usually difficult to locate, and many times can be found only through the behavior of the fish guarding it. Reighard ('06, p. 15) says: "They are much less conspicuous than the nests of the Small-mouth Bass and are usually less excavated. Often the bottom is covered with dead leaves, fallen from neighboring trees, and the fish has merely swept away the thin layer of ooze from these and the eggs have been laid upon them. In other cases the roots or low growing shoots of water plants have been similarly cleaned. Sometimes an area of sandy gravel has been swept clean, but has not been hollowed out nor has the sand been removed from among the pebbles. All such nests are inconspicuous and are usually found only by first observing the presence of the male bass. In but one case have I seen a Large-mouthed Bass on a nest that was well hollowed out and in which the sand had been removed from among the pebbles at the center of the nest. This was, however, in a pond in which Small-mouthed Bass were also present, so that the work may have been in part that of a Small-mouthed Bass." Evermann and Clark ('20, p. 417) describe the nests as circular depressions filled in with pebbles from about the size of a hen's egg down, and the nests as about 2½ feet across. Hankinson ('08, p. 214) describes the nests found at Walnut Lake as circular masses of blackened bulrush roots. Bensley ('15, p. 41) says, "The fish construct nests, by fanning out huge basins with the fins, sometimes three feet in diameter and a foot into the bottom." Nash ('08, p. 89) also describes the nests as made by scooping out sand and mud. Richard-

son ('13, p. 414) found the nests to be well-excavated, nearly round (12-18 in. across) and with grass roots at the bottom. Forbes and Richardson ('09, p. 268) say that the nests are built by the males among fallen leaves or fibrous rootlets in sand or gravel. Spawning has apparently not often been observed, which may be due to its taking place at dusk, according to Reighard ('06, p. 15) who gives an account of spawning in artificial ponds near Grand Rapids, Michigan. The female in this case was somewhat darker colored than the male and had a more distended abdomen. "The male was in the nest or near it and repeatedly the female approached. The male circled to her outer side and bit her flank and she then went away. Three or four other bass, probably males, were seen ten or fifteen feet outside the nest. I returned at 7 P. M. and found the same conditions. The female was seen to approach the nest and to turn on her side with her head pointed obliquely downward and to float thus, as though half dead. In this position she entered the nest and the male followed and took up a similar position. What happened in the nest could not be clearly seen. The tails of the two fish could be seen and from their position it was clear that the fish lay side by side on the bottom with their tails together and parallel. It could also be seen that sometimes one and sometimes apparently the other fish lay turned partly on its side. At this time no doubt the eggs were emitted. After being in the nest for a short time the fish came out, and the female was seen to be still floating, head downward. They then returned to the nest and continued thus for half an hour, alternately lying on the bottom within the nest and floating on its border. It was then too dark to make further observations.

"That the male of the Large-mouthed Bass habitually receives more than one female into his nest or receives the same female a second time after a considerable interval is shown by the fact that in three nests in which the eggs were examined in their earlier stages some were found that had been recently laid and others that had been laid for forty-eight hours." Forbes and Richardson ('09, p. 269) hold that the male seeks the female and that the spawning is intermittent. The eggs are adhesive and several thousand are laid by one fish (Smith, '07, p. 247; Lydell, '04, p. 40). They adhere to roots, stones, or other objects in the nest bottom. They hatch in 8 to 10 days, according to Forbes and Richardson ('09, p. 269), but Reighard ('03b, p. 15) says the eggs are hatched usually at the end of three days. They are guarded by the male and sometimes by both parents (Smith, '07, p. 247; Hankinson, '08, p. 214). The young are also attended by the fish during the time they are in and about the nest (Reighard, '06, p. 16; Smith, '07, p. 247). The young may remain in the nest a week or ten days (Bean, '03, p. 492). After leaving it they swim in compact schools. Richardson ('13, p. 415) noted 6000 young in two schools.

Large-mouthed Black Bass may reach a weight of 25 pounds (Bean, '03, p. 492), but seldom do they exceed eight pounds. Embury ('15, p. 227) notes that they may grow to a length of 3 inches in five months; in one year, 5-6 inches, and in two years, 8-10 inches. Nichols and Heilner ('20, p. 1) record the known maximum size of the species to be 16½ lbs., and 34½ inches in length.

Habitat. Large-mouthed Black Bass were very generally distributed in the shallow waters of Oneida Lake and in its tributary streams for short distances

from the lake, and were found under a variety of conditions, but with a very evident preference for areas with abundant plant growth. Except the very young under an inch in length, which were sometimes found in compact schools of thousands, the little Large-mouthed Bass were solitary. The solitary individuals were usually two or three inches long, and out in water four or five feet deep. Large-mouthed Bass near a foot in length were sometimes caught. Fishes of this size appeared to lurk in lily and rush growths of the deeper shoals. The larger bass of the lake very probably live in ten or more feet of water, but few notes on these were obtained.

The Large-mouthed Black Bass is a lake or pond fish, but it often abounds in deep, sluggish rivers and sometimes is found thriving in deep pools of creeks. Forbes and Richardson ('09, p. 267) observed a general distribution in Illinois. They say: "Our data show a fairly equal distribution of this species throughout the various situations open to it, the ratios for lowland and upland lakes, for creeks, and smaller rivers being approximately equal, and those for the larger rivers about half as large." An indifference to warm and muddy water is mentioned. Milner ('74, p. 35) writes of this bass as inhabiting, in Lake Michigan, the zone between shore and the depth of 60 feet, but not the deeper waters. Shelford ('13, pp. 111, 115, 120), in his detailed studies of the distribution of the fish in streams entering Lake Michigan, found it only in the lower courses. In the series of ponds studied in much detail (pp. 139, 156) the species was found only in the one near Lake Michigan. Bean ('03, p. 492) notes that this black bass seeks deep places in cold weather and often hibernates under rocks, sunken logs and in the mud. In the summer its favorite localities are under overhanging and brush-covered banks and among aquatic plants. In such places it lies in wait for its prey. Evermann and Clark ('20, p. 414) found that the Large-mouth prefers lakes, bayous and other sluggish waters, and that in the small lakes of the upper Mississippi Valley it is most abundant in those of moderate or shallow depths. Hankinson ('08, p. 213) found it dwelling chiefly in the pond weed zone in Walnut Lake, Michigan, but in spring it was common in shallow water. Henshall ('19, p. 32) says that it prefers stiller waters than the Small-mouth, is more at home in weedy situations and will thrive in quiet mossy ponds with muddy bottoms where the Small-mouth cannot; but on the other hand the Large-mouth can exist wherever the other can; that "It is better able to withstand the vicissitudes of climate and temperature, and has a wonderful adaptability that enables it to become reconciled to its environment."

Food. The food of a nine-inch Large-mouthed Black Bass taken at Johnson's Bay July 11, 1916, consisted of crawfish fragments, a small fish, and filamentous algae; that of an eight-inch specimen from Podygut Bay, July 17, 1916, of fragments of two small fish that could not be identified.

Forbes ('80, p. 42) gives the results of his studies of the food of thirty-one examples of this species from Illinois (see also Baker, '16, p. 189). The very young, $\frac{3}{4}$ inch long and under, had eaten mostly entomostracans. Larger ones, $1\frac{1}{2}$ inches and under, had taken entomostracans only to the extent of 25%, while the rest of the food was largely insects and minute fish. Two specimens (2-3 inches long) had eaten only insects, chiefly *Corixa* (compare with Hankinson, '20, p. 11).

Four larger specimens ($3\text{--}3\frac{1}{2}$ inches) had also eaten *Corixa* chiefly but nymphs of May-flies in addition. Fourteen adult specimens had apparently taken no entomostracans and only a few insects; they had eaten principally fishes, and "of sufficient variety to show that no group is safe from the appetite of the bass unless it be the gar."

Seven per cent of all the food taken by this species was crawfish. Forbes says: "We may generalize these data by saying that this black bass lives, at first, wholly on Entomostraca; that it commences to take the smallest aquatic insects when about an inch in length, and that minute fishes appear in its diet almost as early. From this time forward, the Entomostraca diminish in importance, and the insects and fishes, become larger and more abundant in the food. The adults eat voraciously of a great variety of fishes—especially the hickory-shad (*Dorysoma*)—and feed upon crawfishes also to some extent."

Pearse ('18, p. 266) examined 78 of these bass from Wisconsin to determine the food of the different sizes, from about an inch to eighteen inches in length, and found them to have fed upon small crustaceans, crawfish, insect larvae, worms, fish, frogs and algae. He concludes that the species feeds more on insects (34.2%) than on anything else, though amphipods (13.9%), entomostracans (18.1%) and fish (8.7%) are also taken in considerable quantities. The young eat more small insects and entomostracans than do the adults. The largest individuals he found ate nothing but fish, crawfish and frogs.

Hankinson ('08, p. 214) determined the food of 24 specimens from Walnut Lake, Michigan, caught between April 11 and June 10. Nearly all had fed on crawfish. Fish remains were found in but five of the lot. One bass taken April 28 had about 350 midge larvae and pupae, besides alderfly larvae and damsel-fly nymphs. Crawfish appeared to be the most important food item for Large-mouth Black Bass in Walnut Lake. Evermann and Clark ('20, Vol. 1, p. 299) found that young nearly two inches long had only fish remains in their stomachs while adult bass contained both fish and crawfish. And even mice have been found in the stomach of Large-mouth Black Bass (p. 236). Bean ('03, p. 492) declared that the young Large-mouth Black Bass feeds on aquatic animals of all kinds suitable in size, including crawfish, frogs, insects and small fish, and that it feeds both at the surface and on the bottom, pursuing its prey with great activity. Emmeline Moore ('20, p. 16) gives a tabular analysis of the food of eleven young Large-mouthed Black Bass which had fed very largely on entomostracans and immature insects, including *Chironomus* larvae, May-fly and Odonata nymphs. Algae are taken in small quantities. Wilson in his studies of aquatic insects finds damsel-fly and dragon-fly nymphs an important food of young black bass, together with imagoes of damsel-flies ('20, p. 228); also water beetles ('24, p. 258). The last named were adults of hydrophilids and haliplids and larvae of dytiscids. These larvae constituted the most abundant beetle food and were found in 14 of the 111 fish (1 to 3 in. long) examined.

Turner and Kraatz ('20) have reported on the food of the young Large-mouth Black Bass in Ohio waters. The character of the food of 141 specimens, measuring from $\frac{3}{8}$ to $3\frac{1}{4}$ inches, is shown in a table (p. 374). Twenty-six kinds or groups of organisms were found in these young bass. Some important gen-

eralizations are made (p. 379): There is a relation between the size of the fish and its food; up to about $1\frac{1}{4}$ inches the food is almost entirely entomostracans and chironomids or midge larvae; from $1\frac{1}{4}$ –2 inches, it is amphipods; and from 2– $3\frac{1}{4}$ inches, amphipods, entomostracans and midge larvae give way to insect larvae and fish.

Pearse ('21 p. 265), from studies of food of 16 specimens, mostly young, from Green Lake, Wisconsin, obtained results similar to those of Turner and Kraatz. The most important food he found was insects (including immature stages), cladocerans, and amphipods. DeRyke ('22, p. 38) found young of this species (1– $1\frac{1}{2}$ in. long) from Winona Lake, Indiana, eating small crustaceans, chiefly amphipods and cladocerans, and immature stages of May-flies and chironomids. He says that with the increase in size, the bass utilizes a large variety of food, until it has reached about two inches in length, when it depends principally upon small fishes for its food. Greeley ('27, p. 64), in two 12-inch specimens taken in the Genesee System in New York, found crawfish in one and a Horned Dace in the other.

Distribution Records. We made the following collections in shallow water (up to three feet), mainly with minnow nets and seines: No. 5, South Bay; No. 76, Constantia; No. 94, bay near Brewerton; No. 118, Big Bay Creek; No. 120, Big Bay Shoals; No. 124, Fairchild's Bay; No. 309, Lower South Bay; No. 314, Coville's Landing, Brewerton; No. 482, East Fairchild's Bay; No. 511, Oneida Creek tributary; No. 546, Chittenango Creek; No. 552, West Vienna; No. 564, Big Bay; No. 577, Three Mile Bay; No. 585, Lower South Bay; Nos. 591 and 4270, Sylvan Beach; No. 599, Coville's Landing, Brewerton; No. 603, Fairchild's Bay; No. 604, near Fairchild's Bay; No. 605, East Shaw's Bay; Nos. 610, 611, Lower South Bay; Nos. 617, 622, 626, Coville's Landing; No. 4200, Maple Bay.

We collected the following in shallow water with trammel nets: No. 524, Short Point Bay; No. 526, Chittenango Creek; No. 542, Johnson's Bay. The following were taken in deep or moderately deep water: No. 144, Grass Island Bar; No. 561, Podygut Bay; Nos. 399, 486, Market specimens; No. 98, found dead.

Pratt and Baker collected the following in moderately deep water, mainly with trap nets: No. 1200, Coville's Landing; No. 1247, Muskrat Bay; No. 1031, Lower South Bay.

Enemies and Disease. Pickerel and Wall-eyed Pike are known to be enemies of the black bass, and very probably they with other piscivorous fishes eat the young of these species in Oneida Lake. We found one Large-mouth (No. 98) with a lamprey scar, and this may have been the cause of its death.

Large-mouth Black Bass are frequently infested with parasitic worms. Pratt ('23, p. 65) in one Oneida Lake specimen found *Neocochinorhynchus* in the intestine, and *Caccincola parvulus* (Marshall and Gilbert) in the pyloric coeca and duodenum. Forty-two specimens of the Large-mouth from lakes near Madison, Wisconsin (Marshall and Gilbert, '05, p. 520), all had worm parasites—Trematodes, cestodes, nematodes, and acanthocephalans. The trematodes are given as *Azygia tereticolle*, *A. loossii*, *Caccincola parvulus*, and *Leucercuthrus micropteri*. Among the cestodes was *Proteocephalus*. Recently Essex and Hunter ('26)

have reported finding fifteen specimens of this bass parasitized with *Acanthocephala* in great numbers, and also with cestodes, nematodes and trematodes (pp. 163, 179). Ward and Whipple ('18, p. 436) record *Proteocephalus ambloplitis* (Leidy) and (p. 546) *Neocchinorhynchus cylindratus* (Van Cleave) from the Large-mouth Black Bass (see also LaRue, '14, p. 285). DeRyke ('22, p. 38) found 32 of 133 specimens of this bass collected in Winona Lake, Indiana, infested with the trematode *Leucercuthrus micropteri* (Marshall and Gilbert.) Some parasitic worms which we found in Oneida Lake specimens of this bass (No. 314) have not yet been identified. Evermann and Clark ('20, p. 299) record *Achtheres ambloplitis* Kellicott and *Ergasilus centrarchidarum* about the gills of this species from Lake Maxinkuckee, Indiana. Wilson ('19, p. 231) records *A. ambloplitis* Kellicott as found on the gill arches. Riley ('15, p. 3) mentions *Clinostomum marginatum* as a parasite of the species.

Economic Relations. The Large-mouth Black Bass together with the Small-mouth are among the most important of our fresh-water fishes from a recreational viewpoint. They are probably the species most eagerly sought by the anglers who fish our inland lakes. The sport of catching them is followed by the pleasures attending the eating of a meaty and delicious table fish. Black Bass sometimes have a weedy flavor in summer; and when taken from shallow weedy lakes or ponds. Skinning the fish will improve the palatability of the flesh (Henshall, '03, p. 15).

Though fewer are now caught than formerly in lake waters near growing centers of population, these fish are holding their own fairly well; and in our more northern waters, where fishing is not so intensive or where their habitats are extensive, as in portions of the Great Lakes, black bass are abundant and are caught in numbers by tourists. In many places they form an important asset to local residents in the attraction they offer to tourists. Where bass fishing is good, the tourists commonly pay well for the opportunity to indulge in the sport, just as they do in regions with good waters for trout or other game fish. As a table fish the black basses are valuable; but they are not legally marketable in New York and other northern states and therefore are not commercial fish. Catches made by anglers, however, even when excessive, are rarely wasted.

Since black bass are no longer commercial fish, at least in New York State, we have no figures to show the cash value in recent years; but it must be very large, especially to railroad, automobile and gasoline interests, and to guides and other persons dependent upon tourist trade. In some parts of the country in former years there were black bass fisheries. Forbes and Richardson ('09, p. 269) show that in 1899 the black bass fisheries in Illinois amounted to 120,000 pounds, of which 102,000 pounds came from the Illinois River.

The culture of black bass in ponds is maintained at hatchery grounds. Since the fish can not be successfully stripped they are induced to nest and rear their young in artificial ponds. According to the last report of the Division of Fish and Game of the New York State Conservation Department (Macdonald, '27, p. 108), no young of the Large-mouth Black Bass have been distributed by the State since 1922.

The Large-mouth Black Bass is a favorable species for pond culture. It grows rapidly and is prolific; and the adults protect their young against many of the

enemies likely to occur in small bodies of water. Jordan and Evermann ('03, p. 358) tell of 37,000 young being found in a pond in the fall, in which 15 adults had been placed the spring before. Johnson and Stapleton ('15, p. 17) advise their culture in bodies of water not smaller than two acres, on account of the size of the fish and their cannibalistic tendencies. Pond culture of Large-mouth Black Bass is attended with certain difficulties, since they need a soft, mucky bottom with roots of aquatic plants, which they clean and to which they attach their eggs. Such conditions are not so easily maintained as clean stony bottoms for the Small-mouth. Sometimes the Large-mouth makes a stony nest, but, as noted by Lydell ('04, p. 40), their eggs are smaller and more adhesive than in the other species; and they are likely when laid on gravel to become lodged between the stones and to stick together in masses and be smothered.

The Large-mouth Black Bass are of some economic importance on account of their injury to or competition with other food and game fish. It is therefore generally considered inadvisable to introduce them into trout waters. Henshall, however, gives instances where trout and black bass have thrived together in streams. In these streams crawfish were abundant, and these crustaceans are preferred by the bass to fish as food (Henshall, '17, p. 121). It is well known that Black Bass associate well with other fishes in bodies of water where an abundance of their favorite invertebrate food is found; but when such food becomes scarce they quickly turn to eating other fishes, and even members of their own species.

On September 9, 1927, we noted large numbers of young (hundreds and perhaps thousands) of this species as well as of the Small-mouth, Perch and other fishes, land-locked in large pools of the broad sand flat along the east shore of Oneida Lake, at Sylvan Beach (Figs. 217 and 218). These pools were separated from the waters of the lake by bars a foot or more in height and about eight to twenty feet in width. It is not likely that the bass and other fishes in these pools would be liberated by wave action before winter; and in all probability they would perish. No doubt conservation interests would find time and effort well spent in seining out the little fishes of value and returning them to the lake.

Angling Notes. Black Bass fishing like trout fishing is an art. It is true that the fish are often caught with simple tackle and with worm or minnow in "still fishing", but a good bass fisherman who gets numbers of them of good size employs studied methods and has special and often expensive equipment. One should read Henshall's ('17) Book of the Black Bass to learn of proper equipment and methods discovered by its author, who has made a life-long study of these fish and the ways to capture them. There are three methods generally employed, which are still fishing, trolling, and casting. All three are used successfully in Oneida Lake. Casting with artificial or live minnow is done near shore usually, along borders of plant growths in the shallower water, often where it is only a few feet deep. Various small fishes are used for bait, and even young Perch, according to Mr. W. A. Dence, give good results; but Creek Chubs, *Scmotilus atromaculatus*, or shiners such as *Notropis cornutus* and *N. atherinoides*, are more frequently used and are probably more suitable on dull days at least than the less brilliant fishes such as young Perch. In Oneida Lake the Large-mouths are caught on a variety of baits other than minnows. Frequently they are taken when fishing for Perch with earth-

worms. Crickets and crawfish are also used with success there. The large nymphs of dragon-flies make excellent bait. They are called "bass bugs" by the anglers and are collected and sold to them by people residing in the locality. Still fishing takes place from a boat, in twelve or more feet of water, with anchor set. In trolling, the boat is rowed slowly, and a long line with a spoon hook or artificial minnow at the end is drawn through the water not far from shore.

References. Baker, '16; Bean, '92, '02, '03, '09; Bartlett, '18; Bensley, '15; Cheney, '97; DeRyke, '22; Dyche, '14; Embury, '15; Essex and Hunter, '26; Evermann and Clark, '20; Forbes, '80, '88b; Forbes and Richardson, '09; Goode, '03; Greeley, '27; Hankinson, '08, '10, '15a; Henshall, '03, '17, '19; Howard, '14; Johnson and Stapleton, '15; Jordan and Evermann, '03; Lydell, '04, '07, '10; Lefevre and Curtis, '12; Marshall and Gilbert, '05; Meehan, '13; Moore, '20, '27; Nash, '08; Needham, '22; Nichols and Heilner, '20; Pearse, '18, '21; Pratt, '18, '23; Reighard, '06, '15; Richardson, '13; Smith, H. M., '96, '97; Shelford, '13; Surber, '13; Titcomb, '08, '17; Townsend, '23; Tracy, '10; Turner and Kraatz, '20; Wagner, '08; Ward and Whipple, '18; Wilson, '19; Worth, '10.

Lepomis incisor (Cuvier and Valenciennes). BLUEGILL. This large and well-known sunfish is poorly represented in Oneida Lake, where we obtained but one record of it and that was a market specimen. None was taken in the many collections we made; and nothing was learned of its occurrence in the lake from fishermen or others familiar with its fishes.

Breeding Habits and Life History. The nests of this species are well known to anglers. They are rather large circular depressions, commonly in the sandy bottom, in two or three feet of water, and occur in colonies. Hankinson ('08, p. 212) found many Bluegill nests in June, at Walnut Lake, Michigan. There were from nine to fifteen in each colony or group. They were found on shoals barren of vegetation, and sometimes among bulrushes in two or less feet of water. Each nest was about two feet in diameter. The eggs were attached to cleaned roots or other objects of the nest bottom. The fish attending the nests were very shy.

Richardson ('13, p. 413) found more than fifty nests of this species in May, in a slough near Havana, Illinois. They were among live willow timber, in water twelve to eighteen inches deep. He says: "The nests were chiefly bunches about the bases of the willows, in some cases as many as a dozen about one tree, all in the shade, and many of them only two or three feet apart. This fish seems particular to select about the same sort of situation for all its nests—a rather hard bottom of sand and mud, with little vegetation, but with some fine dead drift, grass, twigs, etc. The nests are eight to twelve inches in diameter, usually quite round, and the excavation of the bottom soil is always well marked—usually to a depth of half an inch or an inch. . . . The males are much more shy than males of the warmouth bass, but they can easily be seen and identified on nests by approaching quietly." In May, 1911, Richardson found other nests in situations similar to those just described and, in one case, as many as three dozen, in three feet of water, wholly unprotected by timber or vegetation. He tells of a colony of Bluegills roiling the water during the process of nest building. Wright and Allen ('13, p. 5) give the breeding time for the species as May to June 10, and the breeding place as gravelly or sandy shoals.

The Bluegill is the largest of the sunfishes, according to Jordan and Evermann ('03, p. 349), reaching a length of 14 inches and a weight of nearly a pound. The maximum weight is about one and one-half pounds. Stranahan ('12, p. 184) says, "It seems probable that the older and larger females spawn earlier than the smaller and younger ones, and it is apparently established that a single male will occupy the same bed continuously for weeks and even months, accommodating several females during the time."

Evermann and Clark ('20, Vol. 1, p. 397) found Bluegills spawning in Lake Maxinkuckee during the latter half of June, their spawning beds being usually located on shallow bars where the water is four to eight feet deep. The nests were six inches to a foot in diameter.

Embody ('15, p. 227) gives the average length of Bluegills five months old as two to two and one-half inches; at one year, three to four inches; at two years, five to six inches. Bolen ('24, p. 309), from scale studies of 39 Bluegills from Winona Lake, Indiana, found an increase in length of about 77% between the ages of one and two years; about 37% the following year, and 16% the next.

Habitat. Bluegills are characteristic sunfish of small lakes. The many small glacial lakes of the Great Lakes region appear to furnish them ideal conditions for existence. They live in streams but are most common in large ones (Forbes and Richardson, '09, p. 258; Jordan and Evermann, '03, p. 349). In Walnut Lake, Hankinson ('08, p. 212) found the species showing a strong preference for the pondweed zone. In the summer it was confined closely to this zone, but in the spring the fish frequently came to shallow water, shoreward of this zone. Reighard ('15, p. 233) found the species at Douglas Lake in shallow water and among vegetation, and says that it is taken on the hook wherever there is vegetation. Jordan and Evermann ('03, p. 350) say that Bluegills are usually found in five to fifteen feet of water on the edges of bars where there are patches of *Potamogeton* and other plants.

Evermann and Clark ('20, p. 401) tell of the young hiding among *Chara* and weeds near the shore, in shallow water, in winter.

Food. Forbes ('80, p. 53) examined twenty-four examples of this species, finding as their food many of the larger aquatic insects such as caddice-fly larvae, dragon-fly nymphs and many amphipods and other Crustacea, including some entomostracans and crawfish. Some of the specimens contained aquatic plants, constituting about one-fourth of the food—too large a quantity, according to Forbes, to have been swallowed accidentally with the animal matter eaten. Some mollusks had been eaten also. Hankinson ('08, p. 212) examined eighteen of this species from Walnut Lake. They seemed to show a seasonal change of food; spring specimens were taking chiefly caddice larvae, crawfish, *Chironomus* larvae and pupae, May-fly nymphs, and *Sialis* larvae. In summer the principal food was crawfish, grasshoppers, crickets, and other terrestrial insects, with entomostracans. Pearse ('15, p. 12) studied the food of sixteen Bluegills, finding about two-thirds of the food to be crustaceans, chiefly Cladocera; the remainder was largely insect larvae with *Chironomus* prominent.

Pearse ('21, p. 264) reports on examination of the food of eighteen Bluegills ranging in length from about 1½ to nearly 8 inches. The food was nearly half

insects, while mites, crawfish, amphipods, cladocerans, snails, sponges, and plants including algae made up most of the remainder. DeRyke ('22) reports on Bluegills he collected in Winona Lake, Indiana. His summary (pp. 33, 37) shows that 143 fish were studied, their length about $\frac{1}{2}$ -6 inches. Entomostracans and chironomid larvae were the chief food material taken from specimens up to about five inches long. Larger fish showed a more varied diet of aquatic insects, hydrachnids, worms, snails, and vegetable material. Fish eggs constituted a considerable part of the stomach contents of the Bluegills. In three of eight fish examined from Douglas Lake, Reighard ('15, p. 233) found chiefly aquatic plants, among which were recognized parts of *Chara*, *Elodea*, and some that appeared to be *Potamogeton* and Water Milfoil. Some insects, hydrachnids, and ostracods made up the animal food. Reighard concludes as Forbes did that plants form a normal part of the food and are not taken in accidentally with animal matter. Marshall and Gilbert ('05, p. 518) found plant food, *Ceratophyllum*, in nine of twenty fish examined, together with other material such as plankton, insect larvae, gammarids, leeches, and snails. Moore ('20, p. 17) gives the food of advanced fry and fingerling Bluegills from certain ponds at Fairport, Iowa, as cladocerans, copepods, ostracods, chironomids, and damselfly and May-fly nymphs. Wilson ('20, pp. 226 and 227) found both young and adults feeding on Odonata nymphs. Kreeker ('19, p. 446) reported May-fly nymphs and filamentous algae in a specimen from a pond near Sandusky, Ohio. Evermann and Clark ('20, Vol. 1, pp. 297, 400) who examined one hundred and fifty of these sunfishes found that the smaller ones had eaten mostly plankton, *Bosmina*, *Cyclops*, *Daphnia*, insects, and water mites; and the larger ones, many *Chironomus* larvae and water plants. In the fall they have been known to consume *Plumatella polymorpha*, *Riccularia*, and *Chara*.

Distribution Records. Only one specimen (No. 365) in one collection was, so far as we know, taken from Oneida Lake. It was reported caught in May, 1916, and was given to us by H. N. Coville, who had the fish market at Brewerton.

Enemies and Disease. Evermann and Clark ('20, Vol. 1, p. 628) found small Bluegills in the stomach of the Water Dog, *Necturus maculosus*. They note (p. 400) that the species is quite free from animal parasites, probably due in part to the fact that it does not prey on other fishes; but the Bluegill is a sensitive fish and many are killed by water mold (p. 402). LeFevre and Curtis ('10, p. 624) list it as a fish quite susceptible to infestation by mussel glochidia and one which will quickly succumb to infection. Marshall and Gilbert ('05, p. 518) found that seventeen of thirty Bluegills they examined harbored parasites in the form of cestodes, nematodes and Acanthocephala. Colbert ('16, pp. 34, 35) found thirty beached specimens at Douglas Lake, in most of which the gill chambers were infested with parasitic copepods. Wilson ('19, p. 231) found *Ergasilus centrarchidarum* Wright on the gill filaments of specimens from Lake Maxinkuckee; also *Achtheres ambloplitis* Kellicott on the gill arches. These two forms were also found on Bluegills by Evermann and Clark ('20, Vol. 1, p. 298), who in addition record leeches, trematodes, cestodes and Acanthocephala as infesting this species. Magath (Fisheries Service Bulletin No. 29, p. 9) found in the Bluegill a parasitic trematode which has its larval stage in the Kingfisher (*Ceryle alcyon*).

Stranahan ('12, p. 183) considers the Bluegill sunfish comparatively free from disease.

Economic Relations. There can be no doubt that this is a desirable species of fish for Oneida Lake, where efforts should be made to increase it. Suitable habitat is plentiful. Since the species is so poorly represented in the lake, planting should be undertaken. If planted fish fail to thrive, it will probably be because of enemies. In fact it is possible that enemies are the cause of the scarcity of Bluegills there now, and the question should be looked into. Jordan and Evermann ('03, p. 349) recognize its valuable qualities when they say: "As a food-fish the Bluegill is of much importance, and of all the species it is the one most often sent to market, where it always brings a good price. . . . Its flesh is firm and flaky, and possesses a delicious flavor." Johnson and Stapleton ('15, p. 18) state that this species is believed to be the finest pond fish available for private culture, and is adapted to practically all conditions, is prolific and of unsurpassed table qualities. According to these writers, it is easily propagated in connection with Black Bass, Crappie (*Pomoxis annularis*), Calico Bass (*P. sparoides*), Rock Bass (*Ambloplites rupestris*), and Warmouth Bass (*Chaenobryttus gulosus*). Goode ('03, p. 67) says that its habits adapt it especially to cultivation in ponds. Stranahan ('12, p. 183) says on this point: "The sunfish, *Lepomis pallidus*, lends himself to domestication most graciously. In fact he seems and acts as if he wanted to be civilized whether we like it or not. *He is comparatively free from disease*, makes rapid growth when given a little care and proper food and, best of all, is of most excellent flavor and quality with only just bones enough to make us relish the two sides of delicious food that his anatomy carries with a minimum of waste. His rapid growth in popularity, taxing the fish-cultural stations to their utmost limit, attests the truth of this seemingly rather enthusiastic statement." Brown ('26, p. 208) advocates planting Bluegills in ponds that are too small for black bass — ponds of five acres or less.

Angling Notes. The Bluegill is undoubtedly the best of all of our sunfishes for angling purposes and it is easily caught by the novice as well as by the expert, and with simple equipment. It goes in schools, so when one is caught there is possibility of catching more. Jordan and Evermann ('03, p. 349) say that among all the sunfishes it holds the highest rank as a game fish and, "It can be taken at any time in the year, even through the ice in the winter. It bites well during the spring and early summer, while from early July until September it is particularly voracious, and fine catches can then be made. It will take any sort of bait, and can be taken with any sort of tackle. Anglerworms are probably the best bait, either in still-fishing or trolling, but grasshoppers are also excellent. White grubs, small minnows, small pieces of fish or mussel are good; and they can be taken on the artificial fly, or small trolling spoon.

"Most of those who fish for Bluegills do so at anchor and with two long cane poles projecting over either side of the stern of the boat. The line always has a float upon it, its distance from the hook regulated by the depth of the water, and the hook is thrown as far from the boat as possible.

"They do not seize the hook with a rush as does the rock bass, but quietly suck it in, and the fight does not begin until the fish finds that it is hooked, but from then on the fight is of the most vigorous kind, and is kept up to the end with a persistency and viciousness that make the Bluegill 'the gamest of all fishes for its size.'"

Nash ('08, p. 86) considers the Bluegill in proportion to its size a fish of greater fighting qualities than those of any other fresh-water fish we have.

Hankinson has caught many Bluegills in Michigan lakes and has rarely succeeded in getting them with any other bait than earthworms or insects, and never with minnows or fish flesh. Grasshoppers and crickets are readily taken, but are quickly pulled from the hook by little Bluegills that are commonly associated with the larger ones on fishing grounds. In deep water (25 to 30 feet), in late summer, only the large fish seem to be present and here crickets make an excellent bait. They should be used, however, with a small sinker, like a BB shot, and a very small float,—the smaller the better—which should be adjusted so that the bait is near the bottom.

References. Baker, '16; Bean, '03; Bolen, '24; Brown, '26; Colbert, '16; Embury, '15; Evermann and Clark, '20; Forbes, '80; Forbes and Richardson, '09; Goode, '03; Hankinson, '08; Johnson and Stapleton, '15; Jordan and Evermann, '03; Kreeker, '19; LeFevre and Curtis, '10; Marshall and Gilbert, '05; Moore, '20; Nash, '08; Pearse, '15, '21; Reighard, '15; Richardson, '13; Stranahan, '12, '19, '20; Wright and Allen, '13.

Lepomis megalotis (Rafinesque). LONG-EARED SUNFISH. We found this species only in one part of the lake, at the source of the Oneida River at Brewerton. It is probably uncommon in the lake, though little was learned of its true status. Bean ('03) does not record the species for New York, and we have found no records elsewhere of its occurrence in the State. Adult males are easily distinguished from those of other sunfish likely to occur in the region by their long opercular flap. The coloration is somewhat like that of the common sunfish, *Eupomotis gibbosus*, but is even more brilliant. The males are among the most beautiful of our fresh-water fishes.

Breeding Habits and Life History. The Long-eared Sunfish in Oneida Lake was found nesting in shallow water at Brewerton, close to Coville's landing, and near the mouth of Oneida River. Several nests in about a foot of water were saucer-shaped depressions like the nests of other sunfish. The bottom here was of fine gravel, of a character different from any other bottom material in the lake for it had been hauled there for some construction work, probably as a support for a pier. The eggs were on the bottom stones. An adult male in gaudy breeding dress guarded each nest, and small companies of females were moving about in the vicinity. All of the nests were found on this patch of gravel, except one, which was in Milton Point Bay, about a mile northeast of this place. This one exception was situated close to the shore and was similar to the nests found at Brewerton. A male was guarding it, but no eggs could be found. All of these nests were found on July 25, 1916. The attending males were not quite four inches in length; the females were decidedly smaller, nearer three inches long.

Hankinson ('08, p. 212; '10, p. 201) found two nests of this species in Walnut Lake, Michigan, on July 1, 1906. These were in the bulrush zone, in 14 inches of water. The eggs were attached to the roots of the rushes which had been swept clean of the bottom marl. He often found the species breeding in other lakes of Southern Michigan and in the larger streams about Charleston, Illinois. All the nests were very similar to those found at Oneida Lake, in being neat, almost circular depressions, more distinct than those of the Common Sunfish, and smaller, the diameter being evidently correlated with the smaller size of the nesting fish.

Habitat. The nesting habitat apparently includes gravelly bottoms in Oneida Lake, since the few nests found were on gravel beds; but only one nest (at Milton Point Bay) was, as indicated, in a natural habitat; the others were on an artificial gravel bed. No notes were obtained on the haunts of this fish in the lake at any other time than the breeding season.

Forbes and Richardson ('09, p. 255) find Long-eared Sunfish to be inhabitants of creeks and smaller rivers, in Illinois, and to be uncommon in larger rivers and lakes. Hankinson ('13, p. 110) finds it a very common sunfish about Charleston, Illinois, in large creeks and small rivers, but scarce in small streams. It lives in the quiet, deep places in the streams. Hay ('94, p. 259), writing of the fish in Indiana, says that it haunts the quiet pools in clear streams.

Food. Forbes and Richardson ('09, p. 255) state: "Our scanty observations indicate that it feeds on aquatic insects, mostly larvae of gnats and day-flies." Hankinson ('08, p. 212) examined the food of three specimens taken in Walnut Lake on May 9, 1906, and found them to have eaten May-fly and dragon-fly nymphs, caddice larvae and leeches. DeRyke ('22 p. 35) found in one specimen about four inches long, from Winona Lake, Indiana, nine caddice larvae, three *Chironomus* larvae, one beetle larva (Haliplidae) and one snail.

Distribution Records. All of the specimens taken were caught at Brewerton, on July 25, 1916. These are: No. 598, a nesting male, with some eggs taken from the nest he was guarding; No. 599, sixteen examples from the spawning bed at Brewerton; No. 613, eight specimens from this same locality, seven having opercular flaps conspicuously long and being in all probability breeding males, and measuring from $2\frac{1}{4}$ to $4\frac{1}{4}$ inches.

Economic Relations. The flesh of this species is of good quality, but the small size of the fish makes it of little value as a food. However, in regions where there are no larger sunfish it is much sought for, and considerable pleasure attends its capture. Hay ('94, p. 259) says that barring its small size, it is as good as any of our other sunfishes. Jordan and Evermann ('03, p. 347) consider it not essentially different from any of the other smaller sunfishes, either as a pan-fish or in its game qualities. In the streams about Charleston, Illinois, Hankinson has found these sunfish to be vigorous biters, taking minnows as well as worms, and often to be a great nuisance to a person seeking larger fish.

References. Bean, '03; DeRyke, '22; Forbes, '80; Forbes and Richardson, '09; Hankinson, '08, '10; Hay, '94; Jordan and Evermann, '03.

Eupomotis gibbosus (Linnaeus). COMMON SUNFISH. The Common Sunfish is very abundant in Oneida Lake, where suitable conditions for it are extensive. Large individuals, sometimes nearly a foot in length, appear to be abundant in deep water and are sought by anglers who prize them for their beauty as well as for their palatability as table fish.

Life History and Breeding Habits. Like our other sunfishes, this one is a nest builder. The nest is typical of the other sunfish nests in being a more or less circular bottom depression, made by a fanning movement of the tail; and objects too large or heavy to be removed by this method are pulled away by means of the mouth (Leathers, '11, p. 252). The nests are usually as nearly circular as bottom features will permit and in diameter are commonly about twice the length of the fish. A gravid female is brought to the nest by the male, and in the spawning act the two fish apply their ventral surfaces and move about in a circle, the eggs and sperm exuding. Leathers (l.c., p. 253) counted eleven circuits a minute made by spawning individuals, and found that the male remains upright, the female horizontal. Clouds of sperms intermixed with eggs could be seen emitted at intervals, and at such times the female would make quick tail movements, throwing herself into an upright position.

Reighard ('02, p. 575) notes that the male is brighter colored than the female, with brighter vermicular cheek markings, and with black ventral fins while those of the female are yellow; and the dorsal and caudal fins in the male a more brilliant blue. He also noted that the opercular flap in the male is larger. In many observations made on spawning Common Sunfish, Hankinson found the female usually smaller and decidedly lighter in color and less brilliant, resembling the immature rather than the adult male. Apparently it is only the male that constructs and attends the nest (Reighard, '02, p. 575; Bean, '03, p. 485). He guards the eggs against other fishes and other intruders. His boldness at this time is well known, and he goes so far as to bite hands and fingers if held near the nest. The spreading of the gill-covers and the displaying of colors appear to be instrumental in driving away intruders (Reighard, '02, p. 575) as well as in attracting the female. It has been generally assumed that this sunfish and others guard only the eggs and not the young. In this connection the observations of Evermann and Clark ('20, Vol. 1, p. 408) are of interest, with regard to a nest of Common Sunfish found July 7, 1901: "The young were quite minute, transparent objects, the eyes being the most conspicuous part of them. They hugged the bottom quite closely, but were pretty active. Now and then one of them appeared to take a notion to leave the nest, and would swim up toward the surface. Quick as a flash the parent fish would snap it up, and it appeared at first glance as if it were devouring its young, but it was soon discovered that each time it had taken in a young fish it immediately went down to the bottom of the nest, head downward, and spat the young out into the nest near the ground." The eggs adhere to bottom objects such as soil particles, small stones, roots and sticks.

We made no active search for nests of this sunfish at Oneida Lake, although had this been done many could undoubtedly have been found. At East Potter Bay on June 28, 1916, we saw several cleaned areas on the sandy bottom in a

patch of bulrushes (Fig. 190), in a foot or two of water, which were very probably all nests of this species. One of them at any rate was occupied by a large Common Sunfish resting over it and was unusually large for the size of the fish, being about three feet in diameter. The fish was perhaps eight inches in length. The water here was 16 inches deep. Eggs were numerous on the cleaned plant roots in the nest bottom. We preserved some eggs as collection No. 466. The water temperature in these shallows was 73° F.

Embody ('15, p. 227) found this species to be 1.5 inches long at the age of five months, 2 inches at the age of one year, and 3 inches at two years. Evermann and Clark ('20, p. 408) found mature specimens 2.5 inches long. The fish commonly grows to a length of eight inches and a weight of a half pound (Bean, '02, p. 393). The nesting habits of the Common Sunfish are well known to naturalists. In some regions the depression nests with their attending brilliantly colored males are a conspicuous feature in a body of water in late spring and early summer. They are seen by many people and some enjoy watching the fish and playing with them, inducing them to bite their fingers as a manifestation of boldness in defending their eggs. There has been much written on the breeding of this species and some notes from literature are here given.

June and July appear to be the principal months for nesting, but it may begin in May (Abbott, '84, p. 337; Hankinson, '09, p. 213; Forbes and Richardson, '09, p. 262; Wright and Allen, '13, p. 5), and in more northerly regions it may take place as late as August, according to Bensley ('15, p. 40; and Leathers, '11, p. 253). Spawning has been noted in June and July (Hankinson, '08, p. 213; Leathers, '11, p. 253; Embody, '15, p. 227).

The Common Sunfish breeds in quiet waters of ponds and lakes, but sometimes in creeks (Abbott, '84, p. 375). Kreeker ('16) describes large numbers of the nests in a shallow bay of Lake Erie. The species appears to breed always in shallow water, usually under two feet. Leathers ('11, p. 253) records nests at a depth of three feet. The bottom selected is varied in character, being composed commonly of clay, sand, or gravel; sometimes of marl (Hankinson, '08, p. 213).

Habitat. Common Sunfish appear to be very generally distributed in Oneida Lake, at least out to a depth of 18 feet, which is the deepest water in which we made collections and where we secured only large examples. Smaller ones may have been present but escaped through the large meshes of the trap net. Young ones under about three inches in length were numerous in shallow water, especially about plant thickets, but frequently they were seen on the open clean shallows over sandy bottom. Large ones were found, especially in early summer, in very shallow water close to shore, among *Dianthera*, *Calamus* and *Typha* growths. And these larger sunfish were quite common in rush patches where the water was three or four feet deep. The deeper quieter parts of creeks tributary to lakes are frequented by both large and small members of the species. The species is one that apparently prefers the shallower waters of a lake, with areas of abundant aquatic vegetation.

Forbes and Richardson ('09, p. 261) considered the species essentially a pond fish in Illinois, and is most abundant in the small rivers. Henshall ('19, p. 70)

says that "It is partial to clear water, with sandy or gravelly bottom, in the vicinity of weed patches." Bean ('03, p. 485) says that it abounds almost everywhere in the lowlands and the highlands, and in brackish as well as fresh water, and occasionally in salt water on Long Island. Hankinson ('08, p. 213) found it more common in shallow water, in spring, at Walnut Lake, Michigan.

Food. Of twenty-one Common Sunfish, which we examined as to stomach contents, eleven were young ($1\frac{3}{4}$ to $3\frac{1}{4}$ inches), and caught in shallow water. These had all eaten insects and crustaceans, the latter consisting of isopods, amphipods, cladocerans and crawfish. The isopods were especially prominent and had been eaten by six of the specimens. Ten large specimens ($5\frac{3}{4}$ to 7 inches) had taken insects, snails and Entomostraca. Among the insect remains were *Chironomus* larvae, crane-fly larvae, and caddice larvae.

TABLE NO. 19. SHOWING THE FOOD OF YOUNG COMMON SUNFISH OF ONEIDA LAKE AS REVEALED BY STOMACH EXAMINATIONS

Collection number	Length in inches	Locality Oneida Lake	Date 1916	Stomach or intestinal contents
475H ¹	$2\frac{1}{8}$	Long Point Peninsula....	July 29	Insect larvae; one amphipod; one nematode.
475H ²	$2\frac{1}{2}$	Long Point Peninsula....	29	Insect; three or four isopods.
490D ¹	$2\frac{3}{8}$	Three Mile Bay.....	3	25 or more isopods; a few <i>Chironomus</i> larvae.
490D ²	$2\frac{1}{4}$	Three Mile Bay.....	3	40-50 isopods; one amphipod.
490D ³	$1\frac{1}{2}$	Three Mile Bay.....	3	Very few isopods and one amphipod.
490D ⁴	$3\frac{1}{4}$	Three Mile Bay.....	3	Isopod fragments; 1 crawfish fragment.
606B ¹	$2\frac{1}{2}$	West side of Shaw's Bay..	26	5 or 6 amphipods; a few insect larvae; cladocerans; and filamentous green algae.
606B ²	$2\frac{1}{8}$	West side of Shaw's Bay..	26	About 6 amphipods; a few cladocerans; insect larva including <i>Chironomus</i> ; 3 nematodes.
622Q ¹	$3\frac{1}{4}$	Coville's Landing at Brewerton, N. Y.	Oct. 16	A few isopods; small insects and insect fragments; several green alga filaments.
622Q ²	$3\frac{1}{4}$	Coville's Landing at Brewerton, N. Y.	16	Mass of insect legs; some green algae.
622Q ³	$1\frac{3}{4}$	Coville's Landing at Brewerton, N. Y.	16	A beetle larva; a chironomid larva; many cladocerans; several amphipods.

TABLE NO. 20. SHOWING THE FOOD OF THE LARGE COMMON SUNFISH FROM ONEIDA LAKE AS REVEALED BY STOMACH EXAMINATIONS

Collection number	Length in inches	Locality Oneida Lake	Date 1916	Stomach or intestinal contents
144A ¹	7	Grass Island Bar.....	Sept. 9, 1915	Few fragments of insects; a nematode; numerous small eggs of <i>Entomostraca</i> .
403B ¹	6 $\frac{3}{4}$	East side of Shackelton's Point	June 21	1 <i>Chironomus</i> larva; fragments of insect larvae; mollusk material (crushed snails abundant).
470F ¹	6 $\frac{1}{2}$	Bay east of Cleveland Village	28	Fragments of crane-fly larvae and other insects.
489D ¹	5 $\frac{3}{4}$	Three Mile Bay.....	July 3	Caddis-fly cases; insects and insect larvae fragments; minute snails; also a parasitic nematode.
489D ²	5 $\frac{1}{2}$	Three Mile Bay.....	3	Large number of caddice-fly cases; several insects (Diptera).
512B ¹	4 $\frac{3}{4}$	Fish Creek.....	6	<i>Chironomus</i> larvae; insect fragments; one small earthworm; a few filaments of green algae; caddice fly pupae; amphipods.
516F ¹	5 $\frac{3}{4}$	Fish Creek.....	6	Several snails or other mollusk bodies; amphipods.
516F ²	4 $\frac{1}{2}$	Fish Creek.....	6	One small amphipod; fragments of insects, adults and larvae; 1 nematode; amphipods; crushed snails.
524E ¹	6	Short Point Bay.....	8	Caddice fly cases (few); insect larva; legs and wings of insects (Odonata); white bodies, evidently eggs.
542D ¹	4 $\frac{3}{4}$	West side of Johnson's Bay	11	Mass of insect fragments; also snail fragments.

Baker ('16, p. 185) examined 17 Common Sunfish from Oneida Lake. Seven were adults nearly six inches long, from deep water (12-16 ft.) near Constantia. These had been eating snails almost entirely. A considerable amount of crustacean material was found in one stomach. Seven specimens examined were caught in the shallow water of Lower South Bay. These were medium sized (3-5 $\frac{1}{2}$ inches) and had been feeding upon snails and Crustacea, the latter of these forming a proportionately greater part of the food than in the adults from deep water. Baker (l.c., pp. 184, 188) summarized the results of Forbes' ('80, p. 54) studies of the food of this species, those of Hankinson ('08, p. 213, 245) at Walnut Lake and of Reighard ('15, p. 233) at Douglas Lake, Michigan, and those of Marshall and Gilbert ('05, p. 519) at Lake Mendota, Wisconsin. He concludes that the Pumpkinseed "of Illinois waters, Douglas Lake, Michigan, Mendota Lake, Wisconsin, and Oneida Lake, New York, are largely mollusk eaters. Those of Walnut Lake, Michigan, are insect eaters. There may be some, as yet unknown, factors which cause this variation in the food of a typical mollusk-eating fish. It cannot be lack of mollusks in this lake, because eight or more available species are known to live in the lake (Hankinson, '08, p. 235). As bottom inhabiting insect larvae are present and eaten there must be some selection by the fish."

Pearse ('18, p. 260) examined the food of nine Common Sunfish from lakes near Madison, Wisconsin, which measured from $4\frac{1}{2}$ to about $7\frac{1}{2}$ inches. Insects, crustaceans, and snails were the principal food. Leeches, freshwater sponges, plants — including algae — were other material recognized. Henshall ('03, p. 70) notes that it feeds on insects and their larvae, minute crustaceans, and is especially fond of eggs and fry of other species. Krecker ('19, p. 446) found *Chironomus* larvae, beetles and filamentous algae in one of these sunfish. Wilson ('20a, p. 227) records it as feeding on dragon-fly nymphs, and gives Muttkowski's record of *Enallagma hageni* in the stomach of three specimens taken near Madison, Wisconsin. Wilson also gives H. C. Schradieck's notes on the examination of 173 sunfish averaging one inch in length, taken near Fairport, Iowa (l.c., p. 228). Odonata composed 34 per cent of the food contents. Sibley ('22, p. 67) notes a preference for snails, but that a great variety of insects and other organisms are taken by the fish. DeRyke ('22, pp. 34, 39) gives in tabular form the food contents of fourteen Common Sunfish from Winona Lake, Indiana. Snails were the most important item, but insects including chironomid larvae were present in considerable amounts.

Evermann and Clark ('20, Vol. I, p. 407) found the food of the Pumpkinseed at Lake Maxinkuckee to be nearly the same as that of the other sunfishes there. The common isopod, *Asellus*, was the principal food found in spring specimens. Thin-shelled snails and minnows, darters, leeches, sponges, insect larvae, ostracods, water mites, crawfish and dragon-fly nymphs were other items. J. P. Moore ('22, p. 42-45) tabulates the character of the food of 224 Common Sunfishes collected in Pennsylvania, New Jersey and the Palisades Interstate Park of New York. These were principally young, measuring from 18 mm to 97 mm but mostly under 80 mm. The following was the result: mosquitoes in all stages, 9%; chironomid larvae and pupae with some other Diptera, 33%; all other insects, 14%; crustaceans, chiefly entomostracans, 18%; mollusks, 7%; vertebrates, 4%; all other animal matter, 6%; plant matter, 5%; silt and débris, 4%. He says: "The great diversity and richness of the dietary are only partially apparent, however, and it would seem that anything that is edible and obtainable is eaten." Greeley ('27, p. 63) found the food of a small Common Sunfish to be 13 chironomid larvae and one amphipod (*Hyalella knickerbockeri*).

Distribution Records. We made the following collections in shallow water (under four feet in depth), mostly with minnow seines and minnow traps: No. 5, South Bay; Nos. 75 and 76, Scriba Creek; Nos. 79 and 81, Johnson's Bay; No. 83, East Johnson's Bay; Nos. 87 and 88, Chittenango Creek; No. 94, Brewerton; No. 100, Ladd's Bay; No. 113, Big Bay Creek; No. 116, Little Bay Creek; No. 120, Big Bay; No. 121, Ice House Bay; No. 122, Shaw's Bay; No. 124, Fairchild Bay; Nos. 131 and 138, Big Bay; No. 142, Frederick Creek; No. 305, Brewerton; No. 309, Lower South Bay; No. 314, Brewerton; No. 403, East of Shackelton Point; No. 422, East Mathew's Bay; No. 425, Dakin Bay; No. 470, Cleveland; No. 475, Long Point Peninsula; Nos. 490 and 491, Three Mile Bay; Nos. 500 and 502, Lewis Point Bay; No. 515, Fish Creek; No. 523, Short Point Bay; No. 536, near Frenchman's Island; No. 539, near Dunham's Island; No. 547, Chittenango Creek; No. 577, Three Mile Bay; No. 591, Sylvan Beach; No. 603,

Fairchild's Bay; No. 604, East of Fairchild Bay; No. 606, Shaw's Bay; Nos. 617, 622 and 626 Brewerton; No. 4200, Maple Bay.

We collected the following in shallow water (up to 4 feet) with a trammel net: No. 412, Lakeport Bay; No. 469, East Potter Bay; No. 485, Fairchild Bay; No. 489, Three Mile Bay; No. 506, Upper South Bay; No. 512, Fish Creek; No. 516, Fish Creek; No. 524, Short Point Bay; No. 526, Maple Bay; No. 542, Johnson's Bay; No. 600, near Milton Point.

We collected the following with trap nets in deep water (12-20 feet): Nos. 144, 145, 146, 155 and 156, Grass Island Bar.

The following collections were obtained from fish markets, principally from the Brewerton market: Nos. 2, 108, 327, 336, 353, 399 and 601.

The following were collected by Pratt and Baker with trap nets in medium deep and deep water (8-15 feet): No. 1, Lower South Bay; Nos. 1205, 1207 and 1216, Dry Land Point; No. 1233, North of Paddygut Shoals.

Enemies and Disease. Because it spends much time in shallow water and often wanders into marshes this fish is exposed to many enemies, being very probably eaten extensively by fish-eating birds, snakes and other animals. In our collections (No. 2430) there is a large Common Sunfish, 6¼ inches long, which we found in the stomach of a Double-crested Cormorant shot near Henderson Harbor, Lake Ontario, New York. Kendall ('17, p. 27) mentions that it is eaten by the Chain Pickerel, *Esox niger*, and Fowler ('13, pp. 9, 12), by the American Merganser and the Black-crowned Night Heron.

A number of parasites have been found on this species. Ward ('18, p. 395) found a trematode (*Allocreidium*) infesting it, and Wilson ('20, Vol. 1, p. 298) reports two tapeworms from the stomach of a common Sunfish. Wilson ('16, p. 339) found glochidia of *Quadrula plicata* on its gills. Among crustacean parasites which have been found on this sunfish are copepods (Wilson, l.c., p. 339), *Ergasilus caeruleus* Wilson, and *E. centrarchidarum* Wright, on the gills, and *Lernaeocera cruciata* on the fins and outer body. Of five specimens from Oneida Lake, examined by Pratt ('23, p. 65), one was infested with *Clinostomum marginatum* (Rudolphi), and one had several nematodes *spinitectus* in its stomach. Encysted cestodes were found in the livers of three of these sunfish. Stafford ('05, p. 681) reports *Tetraonchus unguiculatus* Way as a parasite of the species and Ryerson ('15, p. 170), a leech, *Placobdella montifera*.

Economic Relations and Angling. The Common Sunfish is often taken by anglers in Oneida Lake, along with Perch. According to Mr. W. A. Dence, it usually is seen in smaller numbers than the Perch, though at times many are taken. In late winter, on bright sunny days, anglers catch large numbers of them through the ice in the shallow water in Big Bay, with earth worms as bait. The fish does not seem to be attracted by other bait in winter; but even at other seasons this bait is the one most likely to entice it.

This Sunfish is an excellent pan fish. As Jordan and Evermann ('03, p. 354) say, "It is eminently the small boy's fish, though it is by no means despised by children of larger growth. Never reaching a size that quite satisfies any one except the boy, yet biting with a vim which makes one regret that it is not larger; for a 2 or 3 pound 'Sunny,' would surely be a fish to try the skill and delight the heart

of any angler." Moore ('22, p. 41) found in his studies "abundant confirmation" of a statement made by Seal and Smith that "this is undoubtedly the most useful species of sunfish as a destroyer of mosquito larvae."

References. Abbott, '84; Baker, '16; Bensley, '15; Bean, '02, '03; DeRyke, '22; Embury, '15; Evermann and Clark, '20; Forbes, '80; Forbes and Richardson, '09; Fowler, '13; Greeley, '27; Kendall, '07; Kreckler, '16, '19; Leathers, '11; Marshall and Gilbert, '05; Moore, J. P., '22; Pearse, '18; Pratt, '23; Reighard, '02; Ryerson, '15; Sibley, '22; Stafford, '05; Ward, '18; Wilson, '16, '20, '20a; Wright and Allen, '13.

Ambloplites rupestris (Rafinesque). Rock Bass. The abundance of vegetation and the extensive areas of rocky bottom in Oneida Lake make conditions especially favorable for Rock Bass, and large numbers of them thrive there and in the larger streams tributary to the lake. The species is among the easiest of our centrarchids to identify, on account of its deep, compressed body, its large mouth, more or less mottled or speckled coloration, and the presence of six or more spines in its anal fin. The Rock Bass often takes the hook and is well known to anglers as one of the smaller game fish.

Breeding Habits and Life History. This fish spawns from April to June, according to Wright and Allen ('13, p. 5), and is typical of centrarchids in that it makes a nest in the form of a slight circular depression in the bottom soil. It appears to prefer gravelly shoals for this purpose (Bean, '03, p. 470; Jordan and Evermann, '03, p. 339; Tracy, '10, p. 118; Hay, '94, p. 254; Smith, '07, p. 234). Bensley ('15, p. 39) says the nest is placed in a swampy bay near shore, often in only a few inches of water. Hankinson ('08, p. 210) found them at Walnut Lake, Michigan, on a marl shoal with a scant growth of bulrushes and in about a foot of water. A few small stoneworts growing on the bottom gave support to the eggs. Bensley ('15, p. 39) describes the nest and nesting as follows: "It is prepared by the male fish, which usually works most energetically, fanning out the sediment with his fins, thus making a basin-like depression, clean of all débris, and of eight or ten inches in diameter. The female is driven into the nest and is carefully guarded until the deposition of the eggs is accomplished. During the process of spawning and fertilization the two fish lie side by side in the nest. Only a few eggs are extruded at a time, and at each period milt is extruded by the male. The operation continues for an hour or more, and at the end of the period the female leaves the nest and does not return. The eggs are carefully looked after by the male, which takes up a position over the nest, and every now and then sets up a fanning motion with the fins. In a few days after the eggs are hatched, the fry gradually rise out of the nest, and are soon left by the male to shift for themselves."

The largest Rock Bass seen by us from Oneida Lake were about eight inches long. In other waters they are known to grow to a length of fourteen inches and to a weight of two pounds, and examples as large as three and three-fourths pounds have been taken (Bean, '03, p. 469).

We often seined small Rock Bass from shallow water. In September, 1915 and 1916, we took eighteen in seven different collections (Nos. 88, 90, 100, 102, 121, 124, 144). They measured from $1\frac{1}{4}$ to $1\frac{3}{8}$ inches in length in June and July, 1916. Twenty-six small fish were caught in five collections (Nos. 427, 529,

539, 543, 546), and these were $1\frac{3}{4}$ to $2\frac{1}{2}$ inches long. It appears that these were of the same generation as those of the September, 1915, collection with the additional growth of ten or more months including a winter. Embury ('15, p. 227) gives these figures on the growth of the young: at five months, average length is $1\frac{1}{2}$ inches; at one year 2 inches; at two years, 3 inches.

Evermann and Clark ('20, p. 390) found the Rock Bass at Lake Maxinkuckee to be one of the earliest spawners, from about May 15th to June 15th. The nest is among rushes in shallow water, or it is placed beside a stick, stake, rock or similar object. The nest is made in clean coarse sand or fine gravel and is eight or nine inches in diameter. The young seem to grow rapidly in Lake Maxinkuckee, those of the year taken July 13 averaging 1.15 inches in total length.

Habitat. Rock Bass appear to be very generally distributed in Oneida Lake, but in shallow water at least they certainly prefer areas with much vegetation and rocky bottoms. They dwell in and about patches of *Dianthera*, *Sagittaria*, *Calamus*, and the like. Our largest collection of Rock Bass (No. 539) which contained twenty small fish about two and one-half inches long, was made along the shore of Dunham Island where there was an abundance of filamentous algae growing on the bottom stones. The species is probably common in deep water. The trap-nets that we saw lifted on Sept. 2, 1915, brought up six large examples of this fish (Nos. 144, 145). These were taken in twelve to sixteen feet of water, off Constantia, where the bottom was rocky. They seem to frequent the larger streams entering the lake and appear to be common in Chittenango Creek. We found them also in Douglas Creek, but not in the large collections we made in Scriba Creek (No. 75), nor in the other small creeks examined.

Bean ('03, p. 469) says of its habitat: "In February and March this fish frequents the mouths of small streams, and in summer it seeks shady places under high banks or projecting rocks. . . . It thrives where there is not much current. . . . It is as common in lakes and ponds as in the streams. Sluggish, pure, dark water suits it best." Nash ('08, p. 83) considers its usual haunts to be dark holes in streams or lakes, where aquatic vegetation flourishes, and it is often found in considerable numbers about docks or timber work that shade the water.

Goode ('03, p. 68) states the species keeps much about sunken logs and roots. Jordan and Evermann ('03, p. 339) give the following as to its habitat: "It is found not only in rivers, but also in the creeks and smaller streams. It prefers clear, cool water, and is therefore least abundant in bayous and shallow, muddy lakes. In the lakes it will be found about patches of *Potamogeton* or other aquatic vegetation. In the streams it most delights to dwell in the quiet water of deep holes where there are large boulders among which some water plants are growing, or about old stumps or logs where the water is three to six or eight feet deep."

Evermann and Clark ('20, p. 387) write that it prefers clear, cool water and that (p. 389) it is pretty generally distributed throughout the lake; but it is usually found in greatest numbers about the patches of *Potamogeton* in five to fifteen feet of water. The young were found in and about patches of *Scirpus* and *Elodea* and of *Chara* and *Najas*. They were frequently raked up in winter near shore, among weeds.

Page ('00, p. 152) says that in its native waters, the Rock Bass is found in winter months under the ice, yet that it stands a high summer temperature, and that it is sometimes found in muddy bayous and in waters stained by decaying vegetation; but it thrives better in clear, pure waters well stocked with aquatic plants.

Food. Baker ('16, p. 182) examined the stomach contents of five Rock Bass from Oneida Lake and found remains of crawfish, amphipods (*Hyalella*), Odonata nymphs, bryozoans (*Plumatella*), algae and other plant material. Hankinson ('08, p. 210) reports food of nineteen individuals from Walnut Lake, as consisting of crawfish, dragon-fly nymphs, *Chironomus* larvae, May-fly nymphs, and, in a single specimen, a small fish. Crawfish (*Cambarus*) were found in ten specimens, and it was apparent that this constituted the most important food of Rock Bass in Walnut Lake. The species is piscivorous to some extent in the Oneida Lake region, for we found a *Percina caprodes zebra* in a Rock Bass (No. 414) that had been taken by hook from Douglas Creek.

Bean ('03, p. 469) states that the species feeds upon worms, crustaceans, and larvae of insects, early in the season; later its food consists of minnows and crawfish. The young feed on insects and their larvae. Bensley ('15, p. 39) states that "The food of the rock bass consists of minnows, crawfish, and insects; the chief food depending on whether the fish is small and inhabiting swampy areas, or large and inhabiting more open shoaly places. During the period when May-flies are abundant, the smaller fish feed largely upon them, leaving their shelters after nightfall, and sucking the flies from the surface of the water." Forbes ('80, p. 47) found that four adults taken at Ottawa, Illinois, in July, had eaten some minute fish which constituted 15% of the food; also water beetles, Neuroptera larvae (over 40%), small crawfishes (about 30% of the food), ephemerids, Odonata and other water insects. Two stomachs contained some plant material (*Potamogeton*) which may have been taken accidentally. Three young Rock Bass under an inch in length were found to contain Cladocera, *Cyclops*, *Chironomus*, and Neuroptera larvae. Two specimens three to four inches long contained 83% *Corixa*. Pearse ('15, p. 14), in five Rock Bass from about one and one-half to four inches long, found the food to be nearly three-fourths insects, including *Corixa*, *Chironomus* larvae, May-fly nymphs and wasps. Other organisms included were Amphipods (*Hyalella*), entomostracans, mites, and plants, including some filamentous algae. Reighard ('15, p. 231) in five of ten Rock Bass examined found fish remains, crawfish (*Cambarus virilis*), and dragon-fly nymphs. One of the fishes eaten was a sunfish. Marshall and Gilbert ('05, p. 518), in 13 of 16 Rock Bass caught in May and June in Lake Mendota, Wisconsin, found insect larvae in two and crawfish in twelve. Nash ('08, p. 83) says: "It emerges toward nightfall and roams about in search of insects, crustaceans, and small fish which form its food." Wilson ('20, pp. 226, 227) mentions Odonata as Rock Bass food.

Evermann and Clark ('20, pp. 296, 389) examined two hundred and sixty specimens of this fish from one to eleven inches long. The smaller specimens, under four inches, had been feeding on plankton, chiefly *Bosmina*, *Daphnia* and *Cyclops*, a few insect larvae, and small fish, including *Schilbodes gyrius*, *Pocillichthys exilis*, *Labidesthes sicculus* and *Notropis whippelii*. The larger speci-

mens, over four inches long, had taken mostly crawfish, minnows and darters. Shells were also found in the stomachs. Sibley ('22, p. 67) found in studies of the Rock Bass from Lake George that it has a preference for crawfish, but small fish, insects and snails were also included. Pearse ('21, p. 262) gives the results of food studies of seven Rock Bass ranging in size from about four to eight inches. Chironomid larvae or pupae had been taken by specimens of all sizes. The smaller ones had fed extensively upon entomostracans, the larger ones on crawfish. Pearse ('24, p. 256) also made studies of the amount of food consumed in a day by Rock Bass confined in aquaria, using ten individuals in his experiment. He found that they consumed an amount equal to 2.46% their own weight. The food consisted of minnows, grasshoppers, dragon-fly nymphs, caddice-fly larvae, crawfishes, amphipods, snails and earthworms. Such studies as these give us something of a basis for calculating the fish productiveness of a body of water like that of Oneida Lake, when taken in conjunction with data on the amount of fish food present, such as found by Baker ('18) for this lake. Greeley ('27, p. 63) says that four of five Rock Bass (5½–10 inches long) contained only crawfish; and another eight inch fish had three young Yellow Perch, each about 1½ in. long, in its stomach, together with fragments of the water plant *Vallisneria*.

Distribution Records. Most of the Rock Bass that we caught were less than three and a half inches in length and were taken from shallow water. Our collections are as follows: No. 5, Lower South Bay; No. 76, Mouth of Scriba Creek; No. 88, Chittenango Creek; No. 90, Maple Bay; Nos. 100, 102, Ladd Bay; No. 121, Big Bay; No. 124, Fairchild's Bay; No. 353, Brewerton; No. 427, Dakin Bay; Nos. 529, 539, Dunham Island; No. 543, Frenchman's Island; No. 546, Chittenango Creek; No. 599, Brewerton; No. 680, Lower South Bay; No. 617, Brewerton; No. 4272, Messenger Bay, Sept. 9, 1927. Larger fish, usually considerably more than four inches long, were taken in the following collections: No. 76, mouth of Scriba Creek; No. 309, Lower South Bay; No. 434, Norcross Point; Nos. 528, 547, Chittenango Creek. The only Rock Bass we got from deep water were in collections Nos. 124, 144. Both were made by trap net near Grass Island Bar, off Constantia, in twelve to sixteen feet of water. Two specimens about a foot long were seen taken from a trap net in eight to ten feet of water at Maple Bay, October 3, 1920.

Enemies and Disease. Forbes ('88b, p. 10 and '88a, p. 511) found a Rock Bass in the stomach of a pike (*Esox lucius*), and Evermann and Clark ('20, p. 584) mention it taken from the stomach of the Water Snake (*Natrix sipedon*). A 5-inch specimen was found in the stomach of a Burbot from Maple Bay, Oneida Lake. Marshall and Gilbert ('05, p. 518) found parasitic worms in thirteen of sixteen specimens which they examined—trematodes in one, nematodes in three, and Acanthocephala in twelve. These authors remark that "The entire absence of cestodes is noticeable." LaRue ('14, p. 144) reports a cestode, *Proteocephalus ambloplitis* (Leidy) found in this species, and Linton ('98, p. 423) mentions *Taenia ocellata* Rudolphi. Faust ('18, pp. 189, 193) found the trematodes *Crepidostomum cornutum* (Osborn) and *Acrolichanus petalosa* (Lander) parasitic upon Rock Bass. Colbert ('16, pp. 34, 35) found thirty Rock Bass beached at Douglas Lake, the gill chambers of which were infested with parasitic copepods. Reighard ('15, p. 232) mentions finding a blind and much emaciated Rock Bass in Douglas Lake. Wilson ('11, p. 189) gives an account of a parasitic copepod, *Achtheres*

ambloplitis Kellicott, which is common on the gill arches of this species; and ('11a, p. 269) in writing of the copepods of the family Ergasilidae, he says that nearly every specimen of Rock Bass is sure to yield such parasites, the number from a single fish often reaching hundreds. *Ergasilus centrarchidarum* Wright also infests this fish, which, according to Wilson (l.c., p. 333), is the most common host of this parasite. Nearly every specimen of this bass examined by him had been found infested to some extent. Both Wilson ('16, pp. 338; '19, p. 231) and Surber ('13, p. 105) note a mussel parasite, *Arcidens confragosus* Simpson, on the species. Lefevre and Curtis ('12, p. 167) found that when Rock Bass was exposed for thirty to forty minutes to glochidia of the mussel *Lampsilis*, it would have from two thousand to twenty-five hundred of these larvae attached to its gills.

Evermann and Clark ('20, Vol. 1, p. 297) found leeches in the mouth and on the fins of Rock Bass, and copepods on the gills, and cestodes and trematodes nearly always present in the stomach and the intestine. They found (p. 389) that the Rock Bass is afflicted with parasites perhaps to a greater extent than is any other species of fish in Lake Maxinkuckee. Infesting this bass here were (l.c., Vol. 2, pp. 79-80) *Argulus maculosus* Wilson, *Ergasilus centrarchidarum* Wright and *Achtheres ambloplitis* Kellicott. Hankinson found considerable prejudice among anglers in the small Michigan lakes against this Rock Bass, or "Wall-eyed Bass" as it was called, for it was said to be "wormy." Pratt ('23, p. 62) found a single trematode, *Crepidostomum cornutum* (Osborn), in the stomach in one of four examples of the species from Oneida Lake. Faust ('18, p. 189) found the same parasite in Rock Bass from Chautauqua Lake, N. Y.

Economic Relations. Rock Bass are good food fish, more popular in some localities than in others. Jordan and Evermann ('03, p. 340) find that "Its flesh is soft and flaky, and is apt to have a muddy taste unless the fish comes from rather cool, clear water. We are inclined to think that those from streams are of better flavor than the ones taken from lakes." Hankinson found it to be inferior to other centrarchids from small lakes in Southern Michigan. Forbes and Richardson ('09, p. 244) consider it above the average as a pan fish but not among the best.

The species is well adapted for pond culture. Johnson and Stapleton ('15, p. 18) consider it well suited for spring fed ponds, together with the Small-mouth Black Bass. Smith ('07, p. 234) finds it is a desirable fish for ponds and one that has been successfully planted in all parts of the country. Bensley ('15, p. 40) considers the species a pest to fishermen in search of Small-mouth Black Bass: "It inhabits the same situations, is of insignificant size and of no fighting qualities; with a propensity for biting on all occasions."

This fish is one that needs special study in Oneida Lake with a view to finding out if its numbers there should be increased—which apparently could easily be brought about. The attitude of anglers toward the species might be ascertained as well as its comparative food value and the extent to which it preys upon or competes with other species of fish in the lake.

Angling Notes. Some sport attends the catching of Rock Bass in waters where there are few better fish; but where black bass, pickerel or other good game fishes are plentiful, the occasional hooking of a Rock Bass is rather a matter of disappointment, for it is too small to be a prize for the table, and lacks gameness.

Jordan and Evermann ('03, p. 339) consider that "As a game-fish it is rather disappointing. It takes the hook with vim and energy and begins a most vigorous fight which, however, it usually fails to keep up. It can usually be caught at any season and at any time of day; good fishing may be had even at night. Any kind of bait may be used, but small minnows, white grubs, and angleworms are best. It will take the trolling spoon quite readily and the spinner and the bucktail also are successful lures. Minnows may be used either in still-fishing or in trolling. During the summer grasshoppers are a good bait, and pieces of freshwater mussel or yellow perch are excellent. In the fall still-fishing with small minnows usually meets with success. Casting with the artificial fly is not a common method for catching the rock bass, yet we have had many good rises and have taken some fine examples in that way; We have also taken it on the artificial frog. Small crawfish also are a tempting bait." Bensley ('15, p. 40) considers it notorious for destroying bait intended for other fish. Bean ('03, p. 470) says that it fights vigorously, but its endurance is not great, and suitable baits are white grubs, crickets, grasshoppers, crawfish and small minnows. Common earthworms also are good bait.

Henshall ('03, p. 54) gives detailed notes on angling for Rock Bass, some of which are as follows: "With a light fly-rod of four or five ounces, and corresponding tackle, and trout flies on hooks Nos. 5 to 7, the rock bass is not a mean adversary. It rises to the various hackles, and to such flies as coachman, brown drake, gray drake, and stone fly, especially toward evening. The flies must be allowed to sink with every cast after fluttering them awhile on the surface. For bait fishing a trout bait-rod of the weight just mentioned, with a reel of small caliber and the smallest braided silk line, will be about right. Sproat hooks Nos. 3 to 4 on light gut snells tied with red silk are the best. Live minnows about two inches long, carefully hooked through the lips, are to be lightly cast and allowed to sink nearly to the bottom and slowly reeled in again. Or if a float is used, the minnow may be hooked just under the dorsal fin. A small float is necessary when white grubs, crawfish, cut-bait, or worms are used as bait. On lakes it is readily taken by trolling with a very small spoon, about the size of a nickel, with a single Sproat or O'Shaughnessy hook No. 1 attached."

References. Allen, '13; Baker, '16, '18; Bean, '03; Bensley, '15; Colbert, '16; Embury, '15; Evermann and Clark, '15; Faust, '18; Forbes, '80, '88a, '88b; Forbes and Richardson, '09; Goode, '03; Greeley, '27; Hankinson, '08; Hay, '44; Henshall, '03; Johnson and Stapleton, '15; Jordan and Evermann, '03; LaRue, '14; Lefevre and Curtis, '10; Linton, '98; Marshall and Gilbert, '05; Nash, '08; Page, '00; Pearse, '15, '21; Pratt, '23; Reighard, '15; Smith, '07; Tracy, '10; Wilson, '11, '11a, '16, '19; Wright and Allen, '13.

Pomoxis sparoides (Lacépède). **CALICO BASS.** Calico Bass (Fig. 215) appear to be rather common in Oneida Lake. It is a handsome fish and looks well on the string; and its good quality of flesh makes it desirable for the table. For these reasons it is much sought after by anglers in regions where it is abundant. In shape, it is much like other sunfish, but is easily distinguished from other centrarchids of the Oneida Lake region by its thin body, large unpaired fins—the dorsal and the anal being much alike in size and shape—and a peculiar color-pattern of dark mottlings on a silvery ground.

Breeding Habits and Life History. Calico Bass are similar in breeding habits to other centrarchids in that they make nests and guard them. Richardson ('13, p. 411) gives an account of one of these found near Havana, Illinois: "May 2, 1911, a nest of this species was found in water 10 inches deep near the north end of Danhole's field. It was hollowed out under the leaves of a water-parsnip, and surrounded by smartweed and bog rush (*Juncus*). Some of the eggs were adhering to fine roots in the bottom of the nest, but most of them were on the leaves of the water-parsnip, at a level of two to four inches above the bottom of the nest. The nest was guarded by a male six inches long, who was so gentle that we could reach out a hand to within three feet of him before he moved away. Eggs taken to the laboratory hatched May third and fourth . . . the great transparency of the new fry, along with their small size, make it very difficult to see them in an aquarium." Wright and Allen ('13, p. 5) give the breeding time for the Ithaca region as May and June, and state that the nest is on gravelly or sandy bottom. Smith ('07, p. 231) states that "The mated fish prepare their nest, and zealously guard their eggs and brood in the same manner as the black basses, remaining with the fry until the latter begins to take food; at times they have been observed to show great pugnacity in defence of their progeny."

Pearse ('19, p. 11) observed about a dozen male crappies on nests in a lagoon of Lake Wingra, near Madison, Wisconsin, on May 20, 1916. The nests were bare places on the bottom, adjacent to aquatic vegetation, and were about two feet below the surface. Four were caught and were nearly ripe, not yet shedding milt. Nests were also found elsewhere in the shallows of the lake on the same day. Nine males which were caught showed that they were feeding actively among shore plants, and "this condition continued throughout the spawning season." Eggs were not found. The fish began spawning when the water was at a temperature near 68° F.

The average weight of the fish is said to be about a pound, with a maximum weight of nearly three pounds (Bean, '03, p. 463). Henshall ('19, p. 75) says that the species prefers clear water and that it spawns in spring or early summer, nesting in sand or gravel or on a flat rock. The largest specimens we saw from Oneida Lake were market specimens (No. 365) nine inches long.

According to Pearse ('18a, p. 360), it breeds during July and August, when the water is warm, and apparently suffers no inconvenience in a shallow lake which warms up rapidly in spring.

The spawning season was found by Evermann and Clark ('20, p. 386) to be the last half of June and the early part of July. Nests somewhat circular in form and eight or nine inches in diameter were placed on small ridges in clean patches of sand surrounded by *Chara*. They were usually composed of coarse sand and fine gravel, with occasionally a few dead shells of *Trisipara contectoides*. So far as observed they were not close to each other, being usually five or six feet apart.

Embury ('15, p. 227) gives the following on the growth of the young: At five months old, average length is 2 to 2½ inches; at one year, 3 to 4 inches; at two years, 5 to 6 inches.

Habitat. The species appears to prefer areas with much aquatic vegetation, according to Hankinson's observations in Illinois and Michigan. Two of the three we took in Oneida Lake had typical environments, one having been caught in the

water lily zone at Paddygut Bay (No. 561), and one (No. 621) near the mouth of the creek at Johnson's Bay, where there was an abundant growth of *Decodon* and *Typha*. Goode ('03, p. 69) says that the preference of the species is for quiet, clear waters, with a grass covered bottom. And it is rarely seen in muddy sloughs and bayous. Nash ('08, p. 83) states that it frequents ponds, lagoons and sluggish streams, where there is an abundance of aquatic vegetation. Forbes and Richardson ('09, pp. cxii, 240) find it inhabiting lakes more than streams, and preferring hard bottoms. Jordan and Evermann ('96, p. 987) say that it is found chiefly in lowland streams and lakes, in cold clear waters, and rarely in muddy bayous. Pearse ('18a, p. 360; '19, p. 6) says the crappie is a specialized fish suited to live among vegetation in shallow water, is adapted to feeding near the surface rather than on the bottom, when there is little wind or heat, and to breeding under conditions which would be unfavorable to most other fishes. He says further ('19, p. 13) that judging from the catches in gill nets and on hooks, crappies are active in Lake Wingra from the middle of February to the middle of October. In autumn, after the temperature falls to about 50% F, they seem to leave the places where they were found during the warmer months, and it is apparent that they go to the deepest water in late autumn and remain there in comparative inactivity during winter. In spring they return to shallower water and remain during summer. The fish is capable of enduring relatively high temperature (l.c., p. 15).

Food. Forbes ('78, p. 76) found the food eaten by ten specimens examined to be chiefly nymphs of May-flies, many gnats and larvae, *Corixa*, gyridid larvae, Cladocera, copepods, polyzoans, and a few seeds and blossoms of trees. Occasionally a small percoid fish was found among the food. Bean ('03, p. 463) says the food consists of worms, small crustaceans and fishes. Marshall and Gilbert ('05, p. 518) found only plankton as the food of three specimens caught in Lake Wingra in Wisconsin. Wilson ('20, p. 226) finds damselfly nymphs eaten by adults of this species. Pearse ('18a, p. 359) in discussing the food habits of this crappie informs us that it feeds largely at night or in the early morning or evening, and in shallow water among plants. DeRyke ('22, p. 35) notes caddice worms and other insect material abundant in four of this species from Winona Lake, Indiana, which measured five to six inches in length. Pearse ('19, p. 6) gives the data on the food of 140 Black Crappies taken from Lake Wingra, Wisconsin: cladocerans, 33%; chironomid larvae, 14.5%; amphipods, 10.9%; chironomid pupae, 9%; fish, 8.8%; ephemerid nymphs, 5.6%; copepods, 5%; adult chironomids, 3.9%; odonate nymphs, 2.3%; *Corethra* larvae, 2.1%. Other food items, each forming less than one per cent of the food of the individual fish are: Hemiptera nymphs; adult Hemiptera; miscellaneous plants; algae; caddice-fly larvae; grasshoppers; beetles; ostracods; unidentified insects; mites; snails; leeches; silt and débris. Pearse (l.c., p. 7) lists nearly a hundred food items obtained from 276 crappies of all sizes. In addition to those not found in the 140 fish are the following: fish eggs; *Dytiscus* larvae, Lepidoptera larvae; and the common hair worm, *Gordius*. From the work of Pearse, it is evident that the crappies feed on a great variety of food, and he makes the following generalizations:

"1. The most important foods are insects (38.6 percent), particularly immature stages; cladocerans (21.2 percent); copepods (19.4 percent); amphipods (7.4 percent; and fish (6.4 percent).

"2. Crappies do not feed much on the bottom. This is indicated by the scarcity of such foods as bottom mud, ostracods, oligochaetes, and insect larvae like *Chironomus tentans*, which typically live on or near the bottom and are abundant in Lake Wingra. The crappie differs from the perch in this respect.

"3. Crappies feed among aquatic vegetation in the open water and to some extent even at the surface. The chironomid larvae occurring in the food are largely those which live in the vegetation along shore, and the same applies to a considerable degree to the cladocerans. The dragon-fly, may-fly, and damsel-fly nymphs eaten are those which are found among aquatic plants. The occasional high percentages of adult midges and midge pupae, with presence of grasshoppers and moths indicate that feeding often takes place at the surface."

There is a seasonal variation in the food of the species, as found by Pearse, who says (l.c., p. 9): "In the spring the food is made up, for the most part, of amphipods, copepods, and cladocerans. During the summer larvae, pupae, and adults of insects are eaten in large quantities, but cladocerans continue to be utilized. In the autumn, cladocerans, small fishes, and chironomid larvae are the chief foods. Adult crappies do not appear to feed in the winter." Evermann and Clark ('20, Vol. 1, p. 296) found plankton and insect remains to be the food of twenty specimens, from Lake Maxinkuckee, Indiana.

Distribution Records. Only three Calico Bass were taken, one in each of the following collections: No. 6, Lower South Bay; No. 561, Paddygut Bay; No. 621, Johnson Bay. From Coville's market at Brewerton, we got the following: No. 365, 10 specimens; No. 486, 8 specimens; all were said to be from Oneida Lake.

Enemies and Disease. Hussakof ('14, p. 2) reports finding a Calico Bass in the stomach of an alligator gar, *Lepisosteus tristachys*. Marshall and Gilbert ('05, p. 518) in examining three specimens of this species found a leech attached to the tongue of one fish and one attached to the roof of the mouth of another. There were also a few small cysts on the outer surface of the stomach. Wilson ('11, p. 333; '19, p. 231) mentions finding a parasitic copepod, *Ergasilus centrarchidarum* Wright, on the gills. He ('11, p. 360) and Faust ('18, p. 191) both note a fluke, *Crepidostomum illinoiense* Faust, in the intestine of this species of fish.

Evermann and Clark ('20, Vol. 1, p. 296) found six specimens of *Ergasilus centrarchidarum* Wright and some leeches in two specimens of this species.

Pearse ('19, p. 14) writes that crappies in Wisconsin Lakes are not heavily parasitized. Of the 276 specimens he examined only eleven carried parasites, and these were intestinal nematodes and trematodes, a leech and some unidentified cysts. He considers the crappie (p. 15) able to live in shore vegetation with much less danger than the Perch, because of its greater immunity to parasites.

Pratt ('23, p. 67) records a single acanthocephalan, *Pomphorhynchus*, from a Calico Bass taken in Oneida Lake; and Van Cleave ('23, p. 82) found *Pomphorhynchus bulbocolli* Linkins in an Oneida Lake specimen.

Economic Relations. Calico Bass are good food-fish commonly prized by anglers and efforts should be made to increase their numbers there, since conditions are favorable. Smith ('92, p. 209) writes of it as an unappreciated species and quotes Jared Kirtland as saying: "From a long and intimate acquaintance with its merits, I hesitate not to pronounce it a fish for the million. As a pan-fish, for the

table it is surpassed by few other fresh water species." The species is a very desirable one for stocking ponds, for it is very adaptable and lives well with other species. Bean ('03, p. 463) declares that "Though a native of deep, sluggish waters of western rivers and lakes, it readily adapts itself to cold, rapid streams, and thrives even in small brooks." Kirtland, as quoted by Smith ('92, p. 209) considers it perfectly adapted to stocking and says that it will thrive in very small ponds of sufficient depth. "It will in no wise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike." Johnson and Stapleton ('15, p. 18) say that it will thrive in company with any of the pond species that are suited to relatively high temperatures.

Angling Notes. Jordan and Evermann ('03, p. 336), in writing of this fish in lakes of northern Indiana, give some notes of interest to anglers: "They bite best in the early spring, in June, and again late in the fall. They may be taken by still-fishing with grasshoppers, worms or live minnows, or by trolling with live minnow on spoon. They will at times rise to the artificial fly and we have seen some fine catches made in that way. Trolling is a favorite mode of fishing for this species in Lake Maxinkuckee. They take the lure with a rush and vim which promises a more exciting fight than really develops, for they soon give up completely and are lifted into the boat without a struggle. At Cedar Lake they are fished for from flat-bottomed skiffs and from sail-boats, with bait of minnows, worms or pieces of fish. When fishing from a sail-boat the angler uses two lines with spoon-baits or 'whirl,' by means of which large catches are made." Henshall ('03, p. 75) says: "The usual method of angling for this fish is from an anchored boat on ponds or small lakes, or from the bank. At times it rises pretty well to the fly, and trolling with a very small spoon is also successful on lakes. The lightest rods and tackle should be employed, with hooks Nos. three to five on gut snells. A small quill float is useful in very weedy ponds with mossy bottom. The best bait is a small minnow, though grasshoppers, crickets, crawfish, cut-bait, or worms are all greedily taken. Fly-fishing is more successful during the late afternoon hours until dusk."

References. Bean, '02, '03; DeRyke, '22; Embury, '15; Evermann and Clark, '20; Faust, '18; Forbes, '78; Forbes and Richardson, '09; Goode, '03; Hay, '94; Henshall, '03; Hussakof, '14; Johnson and Stapleton, '15; Jordan and Evermann, '96, '03; Marshall and Gilbert, '05; Nash, '08; Pearse, '18a, '19; Pratt, '23; Richardson, '13; Smith, '92, '07; Van Cleave, '23; Wilson, '11, '19; Wright and Allen, '13.

Labidesthes sicculus Cope. BROOK SILVERSIDES, SKIPJACK. (See Fig. 214.) We saw large schools of Brook Silversides in the shallow water along the shore of Oneida Lake, in September, 1915; but no schools were noted there in June and July, 1916. The fish were probably over deep water then. The species is easily distinguished by its small size, very slender, somewhat translucent body, long beak-like jaws and the two dorsal fins. It has a habit of swimming near the

surface and frequently jumping out and skipping along over the water. This habit has given them the name "Skipjack."

Breeding Habits and Life History. Few notes were obtained on the breeding of the Silversides in Oneida Lake. Those taken in September, 1915, were undoubtedly young of the season for they were all small, uniformly sized specimens from $1\frac{1}{2}$ to 2 inches long. The four Silversides taken at other seasons, April, July, and October, were $2\frac{3}{4}$ to $4\frac{1}{4}$ inches in length. Four and a half inches is near the maximum size of the species. Cahn ('27, p. 73) studied the growth of this species in Oconomowoc Lake, Wisconsin, from the average size of 11.2 mm to a maximum size of 76.2 mm.

The species breeds about Ithaca in May and June, in quiet lakes, streams and ponds. Its eggs bear filaments (Eigenmann, '18, p. 1044) attaching them to vegetation, according to Wright and Allen ('13, p. 5). Richardson ('13, p. 411) found fry $\frac{1}{4}$ – $\frac{3}{8}$ inches long abundant and in schools in June, 1911, near Havana, Illinois. He says that they swim near the surface with a characteristic wiggling movement, seeming to keep in the open spaces between the smartweed and the *Potamogeton*. In spawning, the fish of a pair evidently wind in and out among water plants. Evermann and Clark ('20, p. 378) say that it probably spawns in Lake Maxinkuckee in the latter part of June and through July. Hubbs ('21, p. 270) made an intensive study of this species in 1920, in Portage Lake and adjacent waters in southern Michigan, including the Huron River. He found the breeding activities at their height during the last of May and early June, after the surface waters had been heated above 68° F. Spawning occurred in the shoals of the lake and in the Huron River. "The most densely populated breeding area was the moderate current of the river, over a washed gravel bottom," at depths of about one to four feet. He gives the following account of the spawning activities: "Particularly after the height of the breeding season, the males in these spawning areas were shown by frequently repeated observation greatly to outnumber the females. Single males were at all times numerous here, but the only females observed were paired with from one to several males. Each male appeared to command a rather illdefined area of surface water, in moderate current two to four meters long by one or two meters wide. From this area each guardian male vigorously drove off invading males, returning later, though not invariably, to approximately the same spot. During the height of the breeding activities, however, no such areal restriction of individuals was apparent, for most or all of the males as well as the females were engaged in their wild spawning.

"Apparently upon entering the spawning area, the females were quickly recognized as such by the males, who gave chase. The female in all cases first made away at high speed very closely pursued by one to several males. Usually she leaped through the air, often repeatedly, in what appeared to be her vigorous efforts to elude the pursuing male. Only once was the actual spawning act observed, but at such close range and under such conditions of illumination that the details of movement could be closely followed." The eggs are extruded considerably above the bottom and sink very slowly; they are well supplied with oil globules and with a flotation organ in the form of a long filament. Hubbs thinks that an egg must be

transported some distance by water currents, and doubtless adheres to the first object with which it comes in contact; and "in the spawning area most closely observed, this object would necessarily be a grain of current-washed gravel; in other areas, it would be some plant in the submerged vegetation." The many notes carefully gathered by Hubbs on the life history of this species suggests to him the following conclusion: "That *Labidesthes sicculus* is a fish characterized by an annual life-cycle, breeding but once at the age of one year, then dying and leaving the young-of-the-year as the only link over the winter connecting the generation of one year with that of the next." Cahn ('27, p. 93) concludes that individuals live from fifteen to seventeen months. He also (p. 64) gives many notes on the breeding of this species in Wisconsin Lakes. The season was May and June, the time correlated with the temperature of the water. The spawning began at 68° F and reached a climax at 72.9° F, in Oconomowoc Lake (p. 66). The fish first were seen in pairs, the male swimming above the female (p. 64). During the height of the spawning season several males may be with a female, "but this poly-association usually terminates by one of the males driving away the others." Cahn vividly describes spawning as follows: "A school of silversides reveals a wild sight when spawning activities are in full sway. In and out dart the females, pursued by one or more males, darting this way and that, shooting an inch or more out of the water and landing again three or four inches from the spot of their emergence amid a spatter of spray, followed immediately by the attending male retinue. Suddenly the female slows down her pace and comes to what amounts to a *comparative* rest. The first male to reach her approaches from the rear and draws up along side. This apparently is a signal for the departure of any other males that may be pursuing that particular female, for never have I seen any disturbance once a male is associated along side of a female. Other males simply disperse and join the chase of other females."

Habitat. There is undoubtedly a seasonal change of habitat for we found the species abundant in shallow water in September, 1915, and scarce there during June and July, 1916, when we found but one specimen (No. 585), July 20, at Lower South Bay. Evermann ('01, p. 348) notes a seasonal movement in small lakes of northern Indiana, but this appears different from the one in Oneida Lake. He says: "It goes in large schools which, during the summer, may be seen swimming at the surface out in the lake far from shore; while during the spring and late in the fall it comes in near shore, where immense schools may be seen, and where it remains even until after the ice begins to form."

We found the schools of this species in Oneida Lake chiefly over sand and stony bottom, and in all cases where vegetation was scarce. Osburn ('01, p. 76) considers it to favor sandy or gravelly bottoms in the shallow waters of lakes and it is found near the surface of deep water (Bensley, '15, p. 38). Radcliffe ('15, p. 13) says that it lives under a variety of conditions, but occurs in greatest abundance in small sluggish rivers, muddy lowland lakes, ponds, swamps, and sloughs. Evermann and Clark ('20, Vol. 1, pp. 285, 376) note a shoreward migration of the species in the fall and (p. 376) say that in summer it is pretty well distributed throughout the surface waters of the lake, "where they can frequently be seen jumping out of the water in low horizontal curves, a whole school some-

times jumping at the same time and forming a very attractive spectacle." Hubbs ('21, p. 263) found a remarkable difference between the habitat of the young and the adult of this species. He found that soon or immediately after hatching on the shoals of the inland lakes he studied in southern Michigan, the young fish moved outward "to assume a pelagic habitat over deep water," and only rarely during the first month of their existence were they seen to return to the shallow waters, although "they were repeatedly and carefully sought for there." Often they were most abundant over the deepest part of Portage Lake where the water was near a hundred feet deep. In streams Hubbs found the young would keep over the deepest part of the quieter stretches, away from the shores. It was evident that during August and September the young return to shallow water, "at first intermittently but soon permanently." The adults showed a "practically exclusive selection of the shoal community. . . . Not once was an adult seen over the deep lake water associated with the young." Cahn ('27, p. 64) makes similar observations to those of Hubbs concerning the habitat of this fish. The adult was found to live entirely in shallow water and the young, up to two-thirds adult size, live over deep water, but both young and adult live at all times near the surface. He says: "Both young and adults are surface species, living normally within less than a meter of the surface of the water, and spending most of their time within ten or twelve centimeters of the surface. . . . The silversides never under any conditions descend below the upper meter of water, this being the maximum depth sought by the adults, while nothing can drive the immature individuals more than a few centimeters below the surface. Hence the statement that the silversides is the most characteristic of our surface fishes." Cahn notes (p. 69) that the small size of the young fish together with their inconspicuous coloring and transparent bodies afford a protection against enemies both in the water and in the air.

Food. Baker ('16, p. 180) gives the results of the examination of the food of four examples of this species from Oneida Lake, taken in the vicinity of Ladd Point, September 3, 1915. More than 90% of the food was adult midges; the remainder was amphipods, entomostracans, water mites and bryozoans. Forbes ('83, p. 70) in his examination of 25 Silversides taken in the northern and central parts of Illinois found the food to be purely animal matter, a little over half consisting of insects and less than half of crustaceans. About a third of the entire amount constituted larvae of *Chironomus*; the crustaceans were all Entomostraca. Spiders and terrestrial insects, accidentally washed or fallen into the water, amounted to 12% of the food. Evermann and Clark ('20, Vol. 1, p. 378) at Lake Maxinkuckee found the food to be insects and entomostracans. Forbes and Richardson ('09, p. 228) say: "It seems to live wholly on animal plankton, apparently catching its minute prey one by one, as a pike captures fish. Its mouth, though small, is well equipped with teeth, and its gill-rakers are unusually well developed, being numerous, slender, armed with minute denticles, and longer than the gill-filaments. Corresponding to its predacious habit, its intestine is uncommonly short, the whole alimentary canal being considerably shorter than the body without the head." They mention the finding of a small unrecognizable minnow among the

food of a Silversides. Pearse ('15, p. 16) examined 50 specimens in which about half the food was insects and about a third entomostracans, proportions similar to those found by Forbes. Pearse found 10.5% of the food to be plants. Other items noted by him were rotifers, *Diffugia*, and unidentified débris. Wilson ('20, p. 226) found an adult of this species which had eaten dragon-fly nymphs, while Evermann and Clark ('20, p. 378) found Entomostraca in the stomachs of a few specimens of the Silversides.

DeRyke ('22, pp. 34, 39) found chiefly insect material in the food of sixteen Skipjacks from Winona Lake, Indiana. He identified a wasp and some aphids among this material. He noted their surface feeding and saw them jump for winged insects.

Distribution Records. As mentioned above, we found the species common in the shallow water of Oneida Lake only during September, 1915. The following collections were made at that time: Nos. 77, 78, Bullhead Bay; No. 86, Poddygut Bay; No. 92, Lakeport Bay; Nos. 99, 100, Walnut Point; No. 101, Ladd Bay; No. 105, Muskrat Bay.

Four specimens were taken at other times: No. 314, Brewerton, October 18, 1916; No. 353, Brewerton, April 29, 1916; No. 585, Lower South Bay.

Enemies and Disease. The many examples that we got in Oneida Lake showed no evidence of disease. The species is preyed upon by larger fish (Bean, '92, p. 101; Nash, '08, p. 79). In some localities the mortality of Silversides is great, due to storms which wash large numbers of them ashore (Evermann, '01, p. 349). Kirsch ('95, p. 330) notes that the Silversides constitutes a large portion of the food supply of the bass and other food fishes of Indiana Lakes. Evermann and Clark ('20, Vol. 1, pp. 297, 377) found it eaten by Rock Bass, pike (*E. lucius*), hell-divers, terns and Kingfishers. Nineteen young of this fish were found in the stomachs of a Black Tern. It is eaten by the Horned Grebe (p. 487) and by the Pied-bellied Grebe (p. 490). A Red-breasted Merganser (*Mergus serrator* Linnaeus) shot at Lake Maxinkuckee, in November, had its oesophageal enlargement packed full of small fishes, chiefly skipjacks. Water Dogs, *Necturus maculosus* (pp. 623, 626, 628) are also known to devour them.

Economic Relations. In Oneida Lake the species is probably most useful as food for larger fish. It is not first-class as a bait-minnow, yet some success may be obtained with it in catching perch, Bluegills, and Calico Bass, when used dead and with two or three on a hook. It does not live well enough in the bucket to be used to any extent as live bait (Evermann, '01, p. 349). It may compete to an important extent with other and more useful fishes in Oneida Lake, because of its feeding extensively on plankton. Radcliffe ('15, p. 13) says that it should be of value in destroying mosquitoes, but its sensitiveness would make it of little use for stocking bodies of water where mosquitoes breed. It is interesting and unique for an aquarium, but it is kept alive with much difficulty. Hankinson has, however, kept them for several days in running-water aquaria.

References. Baker, '16; Bean, '92, '03; Bensley, '13; Cahn, '27; DeRyke, '22; Eigenmann, '18; Evermann, '01; Evermann and Clark, '20; Forbes, '83; Forbes and Richardson, '09; Hubbs, '21; Kirsch, '95; Nash, '08; Osburn, '01; Pearse, '15; Radcliffe, '15; Richardson, '13; Wright and Allen, '13.

Cottus bairdii Girard. MILLER'S THUMB, COMMON SCULPIN, MUDLER. Little was learned of the numbers of the Miller's Thumb in Oneida Lake, for it is not easily captured in a net. For this reason and on account of the small size of the species and its habit of lying close to the bottom, which it closely resembles, it is not well known to persons who are not students of fish. It is rather grotesque in appearance, having a very large head in proportion to its body which tapers to a small tail. The mouth is very large, and there are curved lateral spines on the head. The skin is naked, except for some prickles behind the large pectoral fins in some examples of the species. This form is not easily distinguished from its near relative, *Cottus cognatus* Richardson, which is abundant in neighboring waters, for example, Onondaga Creek at Syracuse, and which possibly may also be found in Oneida Lake. Specimens on hand are distinguished by the four soft anal rays in addition to the concealed spine, while *C. cognatus* usually has three soft rays.

Breeding Habits and Life History. Gage (Gill, '08, p. 111) found in Cayuga Lake, New York, eggs of a fish that in all probability was this species. The eggs were in irregular conical masses and of salmon color. Each mass was hanging on the lower side of a flat stone in water five or six inches deep, and was guarded by a male. They were found from April to July. Hay ('94, p. 291) quotes J. P. Moore as saying that the eggs of the Miller's Thumb (*Cottus* sp.) in Indiana are laid in masses of one hundred twenty to five hundred and that they cohere firmly, but with open spaces between them allowing the circulation of water and the escape of young from the interior of the mass, which may hatch first. The eggs hatch in May. Hankinson ('08, p. 216) found a cluster of eggs of the Miller's Thumb (probably *Cottus bairdii*) on the under side of a stone on a gravelly shoal in Walnut Lake. Reighard ('15, p. 239) found them in similar situations, and in Douglas Lake he found *Cottus* only in localities that furnished nesting sites. Recently Dr. Bertram G. Smith ('22) has published observations on the nesting of *Cottus bairdii* near Ypsilanti, Michigan. He found egg masses consisting of about 200 eggs each, on the lower surfaces of stones in a small creek, and usually in rather swift water. There was an adult attending the eggs in most cases. Hahn ('27, p. 430) who made observations on the breeding of this species near Ann Arbor, Michigan, says: "At spawning time, the male prepares the nest under a stone or some other favorable object. The nest consists only of a hole, which is provided with a suitable covering and which can be easily protected against enemies. The nest is then visited by one or more females, and eggs are deposited on the under surface of the stone or other object which covers the nest. The female then leaves, and the male guards the nest throughout the incubation period. According to Mr. Carl L. Hubbs, *Cottus bairdii*, in the colder streams of northern Michigan, is more common in the dense patches of vegetation than under stones, and to some degree at least deposits eggs on the plants. In warmer streams he finds it more common under stones, particularly at breeding time. During the breeding season, one may frequently find *Cottus* nests by carefully lifting the stones in a place where the current is rather swift." Greeley ('27, p. 65) mentions the finding of a sculpin with eggs, by Messrs. Smith and Hering, on June 26, at Nigger Spring, Allegany Co., N. Y. The eggs were spherical and in a grape-like mass of about 200. Each egg measured about $\frac{1}{8}$ inch in diameter. The fish may grow to a length of seven inches, according to Jordan and Evermann ('98, p. 1951).

Habitat. Bean ('03, p. 636) writes that the Miller's Thumb abounds in clear, rocky brooks and lakes, is especially abundant in limestone springs, and enters caves. Hankinson ('08, p. 216) has found it confined very closely to rocky bottoms in Walnut Lake and in most other localities, but in the Whitefish Point region ('16, p. 152) they were abundant in thick submerged masses of tapegrass and stonewort, in Shelldrake River, where the bottom was not stony; a few were also taken on sand and mud bottom. In Lake Superior, however, they were found exclusively in the pebble zone, where they were probably common. In Oneida Lake they appear to live wholly on rocky bottoms, but we did not determine definitely their distribution. Probably they are found both in the deep and the shallow water of the lake.

Food. Forbes examined six specimens of *Cottus* (very probably *C. bairdii*) and reported the food to be about 40 per cent aquatic larvae of insects and about 25 per cent small fish, the remainder crustaceans of the genus *Asellus* (Forbes and Richardson, '09, p. 327; Forbes, '83, p. 68; Gill, '08, p. 108). Pearse ('15, p. 15) studied the food of ten *Cottus* (probably *C. bairdii*) and found about two-thirds of the food to be insect larvae and the remainder crustaceans (ostracods, copepods, amphipods, *Hyalella*), midges, leeches, and algae. More recently he ('18, p. 257) reports on the food of thirty specimens, with similar results. Greeley ('27, p. 65) found two specimens of *Cottus bairdii* taken in the Genesee System, N. Y., to have fed upon May-fly nymphs, midge larvae, filamentous algae and diatoms. Turner ('22, p. 95) found 25 young Miller's Thumbs (probably *Cottus bairdii kunulicui* Hoy, since this is the Great Lake subspecies, according to Hubbs ('26, p. 75), from near Put-in-Bay, Ohio, to have eaten midge larvae and May-fly nymphs principally, but in addition, amphipods, fish, beetle larvae, insect eggs, worms, and filamentous algae. Hankinson ('16, p. 152) found a large burrowing May-fly nymph in the enteron of one sculpin taken in Shelldrake River in the Whitefish Point region. The Sculpin is also said to devour trout eggs (Jordan and Evermann, '08, p. 1951; Forbes and Richardson, '09, p. 327).

Distribution Records. All *Cottus* found in our six collections from Oneida Lake were *bairdii*. Only one specimen was taken in each collection. The following collection contained them: No. 90, Maple Bay; No. 406, Leete Island; Nos. 434, 535, Norcross Point; No. 441, Taft Bay; No. 460, stream at Cleveland.

Enemies and Disease. A Miller's Thumb was found in the stomach of an American Merganser (*Mergus americanus*) taken by C. C. Adams and W. E. Sanderson at Cranberry Lake, New York, August 21, 1915. Hankinson ('16, p. 138) took a Sculpin or Miller's Thumb two inches long from a Pike (*Esox lucius*) six inches long. Ward ('11, p. 227) found 183 parasitic worms in forty specimens examined: twenty trematodes, one hundred thirty cestodes, and thirty-three nematodes.

Economic Relations. The Miller's Thumb is of no value as human food. In some regions it is used as bait for black bass (Meek and Clark, '02, p. 138). It is commonly considered destructive to trout eggs but definite food studies to determine the extent of this injury do not appear to be on record. No doubt such studies should be made in regions where the species is closely associated with trout in the spawning season. Possibly it feeds on the eggs of other fish also.

In Oneida Lake the Miller's Thumb may possibly devour Tullibee eggs which are deposited on rocky shoals. This, however, is a matter for further investigation.

References. Bean, '03; Forbes, '83; Forbes and Richardson, '09; Gill, '08; Greeley, '27; Hankinson, '08, '16; Hahn, '27; Hay, '94; Hubbs, '19, '26; Jordan and Evermann, '98; Meek and Clark, '02; Nash, '08; Pearse, '15, '18; Reed and Wright, '09; Reighard, '15; Smith, '22; Turner, '22; Ward, '11.

Eucalia inconstans (Kirtland). BROOK STICKLEBACK, COMMON STICKLEBACK. This is the smallest fish found in the lake (Fig. 202). It is a brook or pond rather than a lake species. The few examples taken were found in very shallow swampy shore waters.

Breeding Habits and Life History. Sticklebacks are noted for the remarkable nest-building habits of the males. Gill ('07, p. 494) remarks: "All the sticklebacks take care of their eggs and the newly born young, but it is the male, and not the female, that exercises parental care; he it is that builds a nest that would do credit to a bird and drives or entices the full female to enter into it and deposit her ripe burden. When a sufficient supply of eggs has been secured, the male closes the nest and remains in charge till the young have reached a size which he considers to be sufficient to enable them to wander away and seek their own living."

We have not been able to find any careful, detail account of the nest-building of *inconstans*. Bean ('03, p. 337) states that "this species is a nest-builder and is vigorous in the defence of its eggs and young," and Eggeling and Ehrenberg ('12, p. 206) say that its habits are like those of allied species. But detailed description based upon accurate and adequate observations on this particular species appear to be wanting. That it produces masses of a jelly-like substance, similar to that produced by other sticklebacks, has been observed in specimens taken from small muddy ponds at Syracuse, N. Y. From these masses the young fish hatched in April. A mass of eggs, presumably of this species, was taken about May 10, 1915, and others were taken in the spring of 1921. They were about an inch in diameter and contained yellow eggs about one millimeter in diameter.

Barker ('18, p. 526) made a study of the breeding of this species at Ithaca, New York. The males were bright in color, having a veiling of black over an olive-green ground color which lightens to yellow on the belly. The females were somewhat lighter in color. Nesting was begun in water of 40°-50° F. in the shallow margins of a pool, in April and May. The nest is always built of materials at hand, such as fine fibers, blades of dead grass, green algae and the like and is consequently inconspicuous. The material is loosely woven together and held in place by a secretion of the kidneys of the male, which hardens into a thread upon contact with the water. He describes them as delicate little structures, spherical in shape, about three-quarters of an inch in diameter, with a hole on one side and fastened to some submerged object like a rootlet or grass blade.

The male fish remains on guard to protect the nest until after the young have hatched. Dr. Barker did not find the fish building in aquaria, but a male which he saw guarding its nest in a pond was captured and with its nest was brought to an aquarium, where the fish continued to guard the nest. The eggs were found by Barker to be almost one millimeter in diameter and transparent and light yellowish in color. They hatched in eight or nine days in water at 65° F. The young at

hatching were about 5 mm long. The young attach themselves by the head for the first few days.

Easily accessible accounts of the interesting breeding habits of other allied species of sticklebacks are given by Gill ('07, pp. 494-506), Jordan ('05, Vol. 2, pp. 229-231), and Seeley ('86, pp. 77-78).

Habitat. The normal habitat of the Brook Stickleback is the shallow water of small streams or shallow ponds; it occurs more rarely in the swampy margins of larger lakes. The conditions of the breeding habitat are not known in detail. There may be seasonal and diurnal migrations as in the case of some other species. Some apparently migrate to the deep water during the day and return to shallow water at night.

Evermann and Clark ('20, Vol. 1, p. 374) found that in Lake Maxinkuckee it appears to dwell in summer in rather deep water, but that at any time of the year specimens could be obtained by dredging in rather deep water, in which case they would become entangled in the long water-weeds in which they appear to dwell. Specimens were obtained by dredging up *Vallisneria* in water thirteen to sixteen feet deep. The best place for them was among long *Nitella*, from a depth of eighteen to twenty-three feet. In the winter they appeared to come near shore and stay among the weeds in shallow water. Barker ('18, p. 529) says that shallow pools that have clear water all the year through, even though they may be choked with vegetation and covered with floating plants during the summer, are likely to shelter these interesting little fishes. Cox ('22, p. 4) records the occurrence of this stickleback in brackish water of land-locked pools, and in saline lakes of North Dakota.

Food. The food of sticklebacks consists of insects, small crustaceans and algae. Gill ('07, p. 496) says that "The eggs and fry of other fishes suffer severely from their attacks, but with apparently equal relish they take worms, the minute entomostracans, the larvae and imagoes of insects, and small mollusks." Forbes ('83a, p. 64) examined the stomach contents of five specimens and found them to contain algae and animal food in about equal amounts. The animal food consisted mainly of Crustacea (*Entomostraca*) and midge larvae (*Chironomus*). Hankinson ('16, pp. 127, 149) found algae and insects in the stomachs of these fish from Whitefish Point, Michigan. The observations of Clark (Cf. Wilson, '07, pp. 423-424) that a European stickleback will eat Crustacea which are parasitic on fish is of special interest. He states: "If hungry or pressed for food the stickleback will sometimes swallow the *Arguli*, but generally speaking they are avoided, and if swallowed are ejected from the mouth."

Woolman ('95, p. 369) says that it eats the eggs of other species and suspects that it has brought about a depletion of fish in certain waters. Evermann and Clark ('20, p. 375) consider the stickleback as carnivorous, subsisting mainly on small animals of the lake. They were found eating insect larvae, Entomostraca and amphipods. Clemens ('24, p. 125) reports on the food of thirteen Brook Sticklebacks. Entomostracans and aquatic insects in variety form the principal food, but much other invertebrate material is present, and the exact character is shown in tables published. One specimen had eaten 98 fish eggs. Pearse ('18, p. 260) in examining the food of 110 of these sticklebacks from Wisconsin lakes

found that they had fed on a great variety of minute animals and some plants; and fish eggs had been taken to the extent of .2%. Entomostracans, dipterous larvae (including *Chironomus*) and snails had been eaten in important amounts. Greeley ('27, p. 63), in one specimen from Monroe County, N. Y., found 60% of the food to be young aquatic insects (Zygoptera, Chironomidae); 20%, Crustacea (*Cyclops*, Cladocera, Ostracoda; 8%, water mites; and 12%, snails.

Distribution Records. The few collections of this fish from Oneida Lake are as follows: Nos. 416, 418, 620, Lakeport Bay; No. 498, Messenger Bay; and No. 500, from the bay west of Lewis Point. At Syracuse, N. Y., collections (Nos. 14 and 350) were made from a small pond, through which flowed a small Oneida Lake tributary stream.

Enemies and Disease. No records have been found of other fish preying regularly upon the Brook Stickleback, although it would seem that this must be of frequent occurrence. Pope ('08, pp. 7, 17-18) learned that in Devil's Lake, N. D., they were "seen to be caught by the thousands by gulls and terns. Immense flocks of black-headed or laughing gulls (*Larus atricilla*) and common terns (*Sterna hirundo*) rear their young on the rocky shores and islands of the lake and feed upon the sticklebacks and minnows." Evermann and Clark ('20, Vol. 1, p. 296) found one in the throat of a Large-mouthed Black Bass.

The worm parasites of European sticklebacks are better known than those of American species, and are suggestive of what to expect here. A tapeworm, *Schistocephalus gasterostei* Fab., is recorded from *Gasterosteus*, figured by Pratt, ('16, p. 194; Cf. Stiles and Hassall, '12, p. 304). The larva is found in fish and frogs, and the adult in water birds. Another tapeworm, *Proteocephalus flicallis* Reed, is recorded from *Gasterosteus* (Leidy, '04, p. 188; LaRue, '14, p. 38), and a parasitic entomostracan, *Lernaea*, has been taken on sticklebacks in Europe (Wilson, '17, p. 195). A sporozoan, *Henneguya* (Cf. Mavor and Strasser, '16, p. 680), is known from *Gasterosteus*. The scant information available on the subject is evidence of the neglect of this common species.

Economic Relations. This fish is too small to be of much value as an individual, but in some localities stickleback schools are so abundant as to be of value as food for domestic animals and for man, as a source of oil, and as a fertilizer (Cf. Gill, '07, p. 496). No definite information is available as to the economic value of the Brook Stickleback. The pugnacious disposition of the species, their egg eating habits, and their harboring of parasites which also infest other and more valuable fishes, are phases of their habits and economics needing investigation.

Sticklebacks are frequently kept in aquaria, but in spite of this, little seems to be recorded of their behavior. Reighard ('10, p. 1119) reports that he has not been able to breed them in aquaria; and Bean ('03, p. 337) states that "This freshwater stickleback appears to live better in balanced tanks than in flowing water and is not hardy in captivity." Barker ('18, p. 526) notes that it thrives when fed on bits of angle worms or tiny pieces of fresh meat.

References. Barker, '18; Bean, '03; Eggeling and Ehrenberg, '12; Forbes, '83, '83a; Gill, '07; Greeley, '27; Hankinson, '16; Jordan, '05; LaRue, '14; Leidy, '04; Mavor and Strasser, '16; Pettit, '02; Pope, '08; Pratt, '16; Reighard, '10; Seeley, '86; Stiles and Hassall, '12; Wilson, '07, '17; Woolman, '95.

Lota maculosa (LeSueur). BURBOT, LING, LAWYER, EELPOUT. The Burbot is the only member of the cod family, Gadidae, found in fresh water. It is easily distinguished by the possession of three barbels, one by each anterior nostril and one on the middle of the chin. The caudal fin is rounded and the second dorsal and the anal fin is long and low, while the first dorsal is very short. The body is slender and somewhat Eel-shaped, and the scales are numerous but very minute.

Bean ('02, p. 448) states that the Burbot is abundant in the lake. The testimony of net fishermen, fish dealers and various individuals familiar with fish conditions in the lake indicates that it is still abundant there. We found also a number of dead ones.

Breeding Habits and Life History. The Burbot has a long spawning season, extending at least from November to March (Bean, '03, p. 703). The eggs were thought by Bean (l.c.) and Goode ('84, p. 238) to be deposited in deep water; but Nash ('08, p. 104) says this fish runs into streams or onto rocky shallows during the spawning season in spring. It frequents hard or rocky bottom when breeding, according to Bean ('03, p. 703). The species is very prolific. Estimates of the number of eggs in a single female range from 160,000 in a medium sized fish to 670,000 in a very large one (Moore, '17, p. 2). Some eggs of this species were discovered in 1906, by A. E. Prince and A. Halkett (Bensley, '15, p. 50). They are very delicate, like the eggs of the cod and other marine relatives, according to Bean ('03, p. 703), who states further that the eggs of Alaska Burbot are of a creamy yellow color. Hay ('94, p. 294) says that they are deposited loose on the bottom.

The average length of this fish in the Great Lakes Region is about two feet. In Alaska it reaches a length of five feet and sometimes weighs sixty pounds (Bean, '03, p. 703). The young of the species appears to be little known. Goode ('84, p. 238) says: "The young of this species are not described in any American work as far as I know." It was, therefore, with considerable interest that we found a little Burbot (No. 553) one and three-fourths inches long near the mouth of a creek at West Vienna. The water was rapid and clear and the bottom rocky at the place where it was caught. The fish was light olive-green in color on its upper parts and white below. On its sides and on the dorsal and caudal fins, there were many black blotches and spots. Kendall and Goldsborough ('08, p. 64) record the taking of young Burbots 1.9-2.45 inches in length, in pools in a field on Indian Stream in New Hampshire. They write: "We are unable to ascertain that young so small as these have been observed before. They were very delicate, died quickly, and became distorted about the head, although the water in the minnow bucket, in which minnows lived very well, was changed frequently. Their appearance was much like the adult, and easily recognized. Their color was somewhat mottled olive, tip of first dorsal reddish." They also took young Burbots 2.75 to 6 inches in length, in the East Inlet of Second Lake in the same region. Reighard ('15, p. 239) reports taking a young Burbot two and one-half inches long, at the mouth of Carp Creek where it enters Burts Lake, in Cheboygan County, Michigan. It was taken near dense masses of aquatic vegetation.

Habitat. In Oneida Lake the Burbot is an inhabitant of deep water, but it probably comes to shallow water to feed at night, as it is known to do in other

regions (Kendall and Goldsborough, '08, p. 64; Moore, '17, p. 2). Moore tells of its hiding in holes and crannies in the deeper water during the day. Forbes and Richardson ('09, p. 331), on the authority of Brehm, mention similar habits. Bean ('03, p. 703) says, "It is stated that the Burbot is usually found in deep water on mud bottom, except during the spawning season in March, when it frequents hard or rocky bottoms." Goode ('84, p. 238) gives the following on the habitat and distribution of the species: "The Burbot is most abundant in lakes, to wit: The Great Lakes, lakes of New York, Winnipiseogee Lake, and lakes of Maine and New Brunswick. In general terms, including under the name 'Burbot' both the American and European forms, the species may be said to inhabit the fresh waters of the northern regions both of Europe and America, being particularly abundant in the Great Lakes and in all ponds, lakes, and large streams, thence northward to the Arctic Circle. . . . The Burbot is not known to enter brackish waters at the mouths of rivers. According to Mr. W. Ainsworth, Burbots are found principally in deep water and on mud, except during the spawning season, which occurs in March, when they run on rock and hard bottom. This refers to the Lake Ontario Region. . . . In the northern rivers, as a rule, the species is very abundant, though within the limits of the United States, so far as we know, the species is less common in rivers." Jordan and Evermann ('98, p. 294) quote Milner as saying that this fish is sometimes found at a depth of 80 fathoms, but that it occurs at all depths above this level.

Food. Baker ('16, p. 199) found only crawfish (*Cambarus propinquus* and *C. bartoni robustus*) in the stomachs of two fish opened, one of which was from Oneida Lake, but had been purchased in a Syracuse market. Forbes (Forbes and Richardson, '09, p. 332; Forbes, '88a, p. 433; '88b, p. 478; Hay, '94, p. 293) found more than 80% of its food to be fish, including Perch (*Perca flavescens*), pike, and whitefish; the rest was chiefly crawfish, including *Cambarus propinquus*. Forbes ('88a, p. 433) considers "It is extremely voracious, with a wonderfully distensible stomach; and not only captures the most active fishes, such as pike, but will eat carrion, and may even swallow stones. It is reported to be nocturnal in habit, and often to secure its prey by stealth." Bean ('03, pp. 638, 703) also mentions its extreme voracity and its destruction of pike, Perch and whitefish, and adds to the list Lake Blob, *Uranidea formosa*, sunfish and lampreys. These last are taken by the Burbot in Alaska waters. He tells further of large stones found in its stomach, one a pound in weight having been taken. Hubbs ('20, p. 2) reports a cottid, *Cottus franklinii*, from the stomach of a Ling, and Tracy ('15, p. 50) lists trout and herring in addition to Perch, young whitefish and crawfish. Evermann and Kendall ('96, p. 604) give the following notes on the food of the Burbot: "This fish is one of the greatest gormandizers found in our waters. If he can procure food he will not desist from eating so long as there is room for another particle in his capacious abdomen. He is frequently taken with his abdomen so much distended with food as to give him the appearance of the globe or toad-fish. The smallest of the three before me, when my description was made, being sixteen inches long, was so completely filled with the fishes swallowed that their tails were plainly seen in its throat by looking into its mouth. On opening it I found no less than ten dace (*Scmotilus bullaris*), all about the same

size and none of them less than four inches long." In the stomach of a Burbot fourteen inches long, they found thirty darters, *Bolcosoma nigrum olustedi*.

Kendall and Goldsborough ('08, p. 64) tell of its habit of approaching the shore at night to feed, and declare that it subsists to a great extent upon other fishes, their eggs and young. Young examples, $2\frac{3}{4}$ to 6 inches long, had in their stomachs fragments of insects, shells of entomostracans, mites and larval insects, principally the black fly. This with other data on the food of young Burbots makes it appear that they have a diet quite different from that of the adult, being more insectivorous in character. Hankinson ('16, p. 152) found chironomid larvae in the stomach of a Burbot seven inches long, in addition to the remains of five or more small fish. Moore ('17, p. 2) says that at least in early life it feeds on aquatic insects and fish eggs. One fish (No. 4203) $15\frac{1}{2}$ inches long, taken through the ice near Dunham Island, Feb. 19, 1921, had in its stomach 241 May-fly nymphs, 3 small fish, including a Perch $2\frac{1}{2}$ inches long, and indeterminable material. A large Burbot taken in Maple Bay of Oneida Lake by Mr. Joseph Buff, on November 8, 1923, contained a 9-inch black bass. The head was partially digested so that the determination of the species was not possible. Another specimen taken a week later in the same bay contained a 5-inch Rock Bass and bones of other fishes.

Clemens ('24, pp. 146-150) reports the food of 136 Ling from Lake Nipigon, Ontario, as being principally Ciscoes (*Leucichthys*), these being found in the stomachs of 88 of the Ling examined. Cottids and other fishes were also included, and considerable invertebrate material composed prominently of the crustacean *Mysis*, with chironomids and entomostracans. Surber ('20, p. 85) found the stomachs of Burbots from a Minnesota lake to be distended with eggs of other fishes.

Distribution Records. We secured personally only one Burbot in the region, the small one referred to above (No. 553) and this was taken from West Vienna Creek, July 21, 1916; No. 4203 secured from a fisherman near Dunham Island. W. A. Dence found an $8\frac{1}{2}$ -inch dead specimen in Dakin Bay, Sept. 16, 1927.

Eucemics and Disease. Burbots are sometimes eaten by other fishes. Sir John Richardson found a Lake Trout (*Cristivomer namaycush*) with its stomach crammed with young Burbots (Goode, '84, p. 238), and Milner ('73, p. 39) tells of a trout twenty-three and one-half inches long, taken at Two Rivers, Wisconsin, from the mouth of which projected some three inches of the tail of a Burbot. The head had been digested away, but the body was fourteen inches long without it. We found dead Burbots in Oneida Lake with lamprey scars upon them. Baker ('16, p. 199) records finding two tapeworms and one hundred sixteen other worms (probably all parasitic) in the specimens he examined. Ward ('11, p. 227) records two hundred forty-seven parasitic worms in three Burbots examined. There were eleven trematodes, fifty-six cestodes, and one hundred eighty Acanthocephala. LaRue ('26, p. 285) found larval trematodes in the eyes of Burbots from Douglas Lake. Bean ('97a, p. 372; '03, p. 702) notes that the fish is easily attacked and overcome by fungi. Cole ('05, p. 579) found leeches common on the Lawyer in Lake Erie. Dence found on the dead Burbot in Dakin Bay, a good many leeches on its fins. The fish was in fresh condition. Preble ('08, p. 378) found a Kingfisher attempting to swallow a Burbot seven inches long.

Economic Relations. As a source of human food, the Burbot appears to be a fish of the future. Senseless prejudices against using it for the table exist in many localities, which seem to be based largely upon its somewhat unfishlike appearance and perhaps its unpleasant odor (Bensley, '15, p. 50). The flesh is, however, not considered of poor quality by those who have given it a fair trial. In some localities it is evidently not so good as it is in others, for Bean ('03, p. 704) says that the quality of the flesh appears to depend chiefly on the nature of its habitat. In cold, northern waters it is probably best. It is considered a good fish in Maine and New Hampshire (Kendall and Goldsborough, '08, p. 63). In Montana, it is in great demand, and in the Yukon and other regions in the far north the flesh is eaten by some people and the liver is considered a delicacy. The roe is also used as food in parts of the North. In some localities the Burbot is highly esteemed when caught through the ice (Bean, '03, p. 704; Nash, '08, p. 104). There is said to be a good market for the Burbot in Chicago, which is supplied by fishermen in the southern part of Lake Michigan. In many other parts of the Great Lakes, fishermen are obliged to throw the fish away or feed it to hogs for it is commonly considered worthless, except for the livers which are occasionally eaten (Bean, '03, p. 703). Despite all this dislike for the Burbot its fishery is of some importance. In the United States in 1908, the catch amounted to 326,000 pounds and was valued at \$4,500 for that year (Durand, '11, p. 27).

Jordan ('82, p. 996) says that the flesh of the Burbot is fairly good, although rather tough and lacking in richness, ranking with that of the catfishes, but considerably better than that of the suckers. Moore ('17, p. 2) considers the meat of the Burbot to resemble that of the cod and the haddock. He gives thirteen recipes for preparing it. Smith ('92, p. 215) quotes Charles H. Strowger, of Nine-Mile Point, New York, as saying: "I split open a dozen, rubbed them with salt, and dried them in the sun. They dried quickly and became very hard and developed the smell of codfish. When cooked they smelled and tasted like salt codfish, and I have no doubt that by curing them in the same way that codfish are treated no one but an expert could distinguish them from salt codfish, except from the shape of the tail. As thousands of these fish are thrown away every day, it strikes me that attention called to the question of curing them properly would result in considerable addition to the earnings of our lake fishermen."

That Burbot in Oneida Lake constitute an important supply of little used human food, is very evident. The writers have been informed by fishermen that the species from this lake is very palatable, and it is very likely that it can be made suitable for the table by some of the ways of preparing it (Moore, '17, p. 2). Their predacious nature undoubtedly makes them detrimental to the production of Perch, Pike Perch, black bass, Tullibees and other high grade fish in the lake. A fair trial, and advertisement of the edible qualities of the Burbot of Oneida Lake may serve to relieve the strain somewhat on a number of other and more highly prized species. More studies on the food of the Burbot in Oneida Lake could profitably be made. Possibly this fish is of some value in its destruction of lampreys, which it is known to feed upon in some regions (Bean, '03, p. 703).

The United States Bureau of Fisheries has been urging the use of Burbots for food, through an extensive distribution of Economic Circulars (Moore, '17)

and display cards. (See Fisheries Service Bulletin 25, p. 5.) Jordan ('05, p. 539) tells of the skin of the fish being used in place of glass in Siberia. In Minnesota, Avery ('18, p. 60) tells of inducing the people to eat over seven thousand pounds of Burbot. It was sometimes camouflaged as "northern catfish." Recently net fishermen (Pratt, '20, p. 63) of the Great Lakes have set their gill nets during summer in deep waters where they are getting Lings in large numbers (43,131 pounds in 1918), and as a result of efforts made by the Bureau of Fisheries these fish are being put upon the market. Durand ('11, p. 204) notes 24,000 pounds of Ling caught in New York State, valued at \$400.

Angling Notes. The Burbot is of little interest to most anglers since it does not appear to be frequently caught with pole and line. It is sometimes taken through the ice (Bean, '15, p. 357; Evermann and Kendall, '96, p. 604), when a number of lines are set baited with live bait. At Oneida Lake large numbers are said to be taken by tip-up fishermen seeking Pike Perch. Frequently the Lings are left on the ice, where they attract large numbers of Herring Gulls which are said to come down to within a few feet of the fishermen. There are reports of substantial windbreaks being made of the carcasses of these Lings during ice fishing. On February 19, 1921, Hankinson saw a fisherman with a Ling which he had caught in about twelve feet of water, about a mile out from South Bay wharf; and on the same date, he saw one caught in twenty-two feet of water, just off Dunham Island. This one was obtained as a specimen (No. 4203). Wagner ('08, p. 37) tells of its being caught in large numbers on set lines in Lake Pepin, Wisconsin.

References. Adams and Hankinson, '16; Avery, '18; Baker, '16; Bean, '92, '97a, '02, '03, '15; Bensley, '15; Clemens, '24; Durand, '11; Evermann and Kendall, '96; Evermann and Latimer, '10; Forbes, '88a, '88b; Forbes and Richardson, '09; Jordan, '82, '05; Jordan and Evermann, '96; Goode, '84; Hankinson, '16; Hays, '94; Kendall and Goldsborough, '08; LaRue, '26; Milner, '73; Moore, '17; Nash, '08; Pratt, '20; Reighard, '15; Smith, '92; Surber, '20; Tracy, '15; Wagner, '08; Ward, '11.

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THE ROOSEVELT WILD LIFE MEMORIAL

As a State Memorial

The State of New York is the trustee of this wild life Memorial to Theodore Roosevelt. The New York State College of Forestry at Syracuse is a State institution supported solely by State funds, and the Roosevelt Wild Life Forest Experiment Station is a part of this institution. The Trustees are State officials. A legislative mandate instructed them as follows:

"To establish and conduct an experimental station to be known as 'Roosevelt Wild Life Forest Experiment Station,' in which there shall be maintained records of the results of the experiments and investigations made and research work accomplished; also a library of works, publications, papers and data having to do with wild life, together with means for practical illustration and demonstration, which library shall, at all reasonable hours, be open to the public." [Laws of New York, chapter 536. Became a law May 10, 1919.]

As a General Memorial

While this Memorial Station was founded by New York State, its functions are not limited solely to the State. The Trustees are further authorized to cooperate with other agencies, so that the work is by no means limited to the boundaries of the State or by State funds. Provision for this has been made by the law as follows:

"To enter into any contract necessary or appropriate for carrying out any of the purposes or objects of the College, including such as shall involve cooperation with any person, corporation or association or any department of the government of the State of New York or of the United States in laboratory, experimental, investigative or research work, and the acceptance from such person, corporation, association, or department of the State or Federal government of gifts or contributions of money, expert service, labor, materials, apparatus, appliances or other property in connection therewith." [Laws of New York, chapter 42. Became a law March 7, 1918.]

By these laws the Empire State has made provision to conduct forest wild life research upon a comprehensive basis, and on a plan as broad as that approved by Theodore Roosevelt himself.

Form of Bequest to the Roosevelt Wild Life Memorial

I hereby give and bequeath to the Roosevelt Wild Life Forest Experiment Station of The New York State College of Forestry at Syracuse, for wild life research, library, and for publication, the sum of or the following books, lands, etc.



Map 16 Map of Oneida Lake showing stations where collections were made. The group of small islands in the middle of the lake is known as Shackleton Shoals.

ROOSEVELT WILD LIFE BULLETIN, Vol. 2, No. 3. March, 1924.

1. The Status of Fish Culture in Our Inland Public Waters, and the Role of Investigation in the Maintenance of Fish Resources.....Dr. William C. Kendall.
2. Current Station Notes.....The Director and Editor.

ROOSEVELT WILD LIFE BULLETIN, Vol. 2, No. 4. February, 1925.

1. The Relation of Wild Life to the Public in National and State Parks.
Dr. Charles C. Adams.
2. The Big Game Animals of Yellowstone National Park.....Edmund Heller.
3. The Food of Trout in Yellowstone National Park.....Dr. Richard A. Muttkowski.
4. Current Station Notes.....The Director and Editor.

ROOSEVELT WILD LIFE BULLETIN, Vol. 3, No. 1. February, 1925.

1. The Birds of the Yellowstone National Park.....Milton P. Skinner
2. Current Station Notes.....The Director and Editor.

ROOSEVELT WILD LIFE BULLETIN, Vol. 3, No. 2. March, 1925.

1. The Muskrat in New York: Its Natural History and Economics.
Dr. Charles E. Johnson.
2. Current Station Notes.....The Director and Editor.

ROOSEVELT WILD LIFE BULLETIN, Vol. 3, No. 3. September, 1926.

1. The Summer Birds of Central New York Marshes.....Aretas A. Saunders.
2. Additional Notes on the Summer Birds of Allegany State Park..Aretas A. Saunders.
3. Current Station Notes.....The Director and Editor.

ROOSEVELT WILD LIFE BULLETIN, Vol. 3, No. 4. October, 1926.

1. The Economic and Social Importance of Animals in Forestry, with Special Reference to Wild Life.....Charles C. Adams.
2. The Land-Economic Survey in Michigan.....R. A. Smith.
3. Current Station Notes.....Charles C. Adams.

ROOSEVELT WILD LIFE BULLETIN, Vol. 4, No. 1. October, 1926.

1. The Relation of Birds to Woodlots in New York State.....Waldo L. McAtee.
2. Current Station Notes.....Charles C. Adams.

ROOSEVELT WILD LIFE BULLETIN, Vol. 4, No. 2. June, 1927.

1. The Predatory and Fur-bearing Animals of the Yellowstone National Park,
Milton P. Skinner.
2. Current Station Notes.....Charles C. Adams.

ROOSEVELT WILD LIFE BULLETIN, Vol. 4, No. 3. July, 1927.

1. A Trout Survey of Allegany State Park in 1922.
William C. Kendall and Wilford A. Dence.
2. A Preliminary Survey of the Fish Life of Allegany State Park in 1921.
Thomas L. Hankinson.
3. Current Station Notes.....Charles C. Adams.

ROOSEVELT WILD LIFE BULLETIN, Vol. 4, No. 4. July, 1927.

1. The Beaver in the Adirondacks: Its Economics and Natural History,
Charles E. Johnson.

ROOSEVELT WILD LIFE BULLETIN, Vol. 5, No. 1. March, 1928.

1. A Preliminary Wild Life and Forest Survey of Southwestern Cattaraugus Co., N. Y.
Victor H. Cahalane.
2. A Preliminary Report on the Trout Streams of Southwestern Cattaraugus Co., N. Y.
Wilford A. Dence.

ROOSEVELT WILD LIFE ANNALS, Vol. 1, Nos. 1 and 2 (Double Number).

1. A Study of the Beaver in the Yancey Region of the Yellowstone National Park.
Edward R. Warren.
2. Notes on the Beaver Colonies in the Longs Peak Region of Estes Park, Colorado,
Edward R. Warren.

ROOSEVELT WILD LIFE ANNALS, Vol. 1, Nos. 3 and 4 (Double Number).
November, 1928.

1. The Ecology and Economics of Oneida Lake Fish.
Chas. C. Adams and T. L. Hankinson.

